MODEL 400E/EL
AC VOLTMETER
Serials Prefixed: 532, 536

OPERATING AND SERVICE MANUAL

HEWLETT hp PACKARD

PRELIMINARY

OPERATING AND SERVICE MANUAL

MODEL 400E/EL
AC VOLTMETER
Serials Prefixed: 532, 536

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P. O. Box 301, Loveland, Colorado, 80537 U. S. A.

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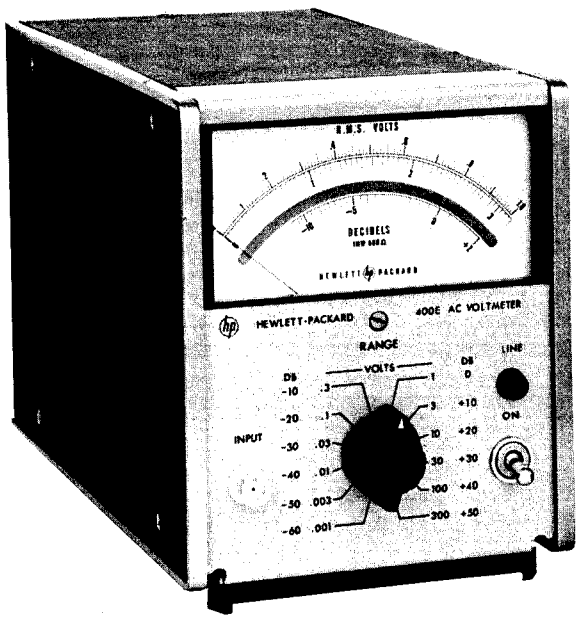
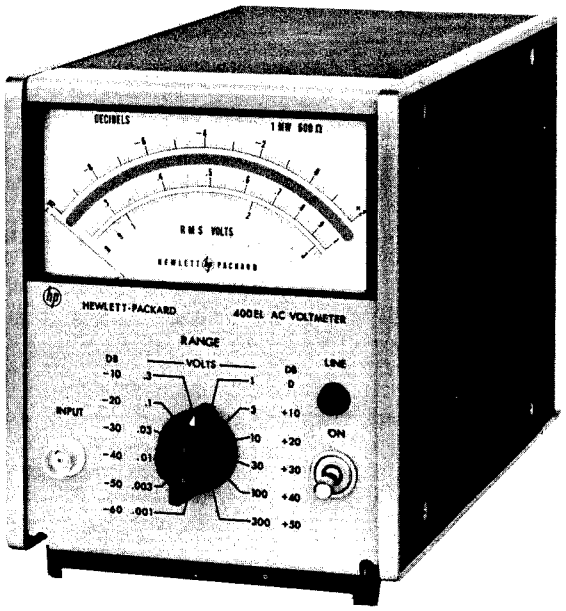
AC VOLTMETERS

models
400E/400EL

TECHNICAL DATA 12 AUG 65





USES

MEASURE 10cps TO 10mc, 1mv TO 300v
DRIVE DC RECORDERS
OR DIGITAL VOLTMETERS
USE AS A HIGH GAIN AC AMPLIFIER

FEATURES

10 MEGOHMS INPUT IMPEDANCE
LOW INPUT CAPACITY
LARGE OVERLOAD CAPACITY
OPTIONS OFFER RELATIVE & ABSOLUTE MEASUREMENT AND CONSTANT INPUT CAPACITY ON ALL RANGES
OUTSTANDING LONG-TERM STABILITY
INDIVIDUALLY CALIBRATED TAUT BAND METER
SOLID STATE

P. O. Box 301, Loveland, Colorado, 80537, Tel. (303) 667-5000
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DESCRIPTION

The hp 400E/EL Solid-State AC Voltmeters are ruggedly built solid-state precision instruments for measuring ac voltages from 1 millivolt to 300 v rms full scale. They cover a frequency range from 10 cps to 10 mc and have constant 10 megohm input resistance on all ranges. Input capacity is 24 pf on the 1 mv to 1 volt range and 9 pf on the 3 volt to 300 volt range. The instruments are simple to operate and give direct voltage and dbm readings.

These ac voltmeters have exceptional long-term stability because their calibration is not dependent on active component parameters which are subject to aging. The 400E/EL may also be used as stable, high-gain ac amplifiers or ac-to-dc converters.

The 400E has all the characteristics mentioned above with 1% of reading accuracy on a 4-1/2" mirror-backed taut-band meter. The meter scale is individually calibrated for its particular movement with 100 divisions to give an added measure of readability.

The 400 EL has all the characteristics above with 1% of reading accuracy on a linear 12 db logarithmic scale. This meter is also individually calibrated with 120 divisions and is ideal for db measurements.

The specifications in the chart on the next page show these compact, lightweight, solid-state voltmeters will give premium performance at an economical price.

CIRCUIT DESCRIPTION

The Model 400E/EL AC voltmeters use high-gain amplifiers having high stability and wide bandwidth. The solid-state metering circuit is stabilized by an overall feedback loop to provide maximum stability. The impedance converter circuit also uses a large amount of overall feedback. These features ensure a high degree of accuracy independent of line voltage changes or other external effects.

AC-to-DC CONVERTER

The Models 400E/EL provide a dc output (1 volt dc for full scale meter deflection) proportional to meter deflection which can be used to drive a potentiometer or galvanometer recorder. This dc output is available at the rear panel of the instrument which is illustrated in figure 1.

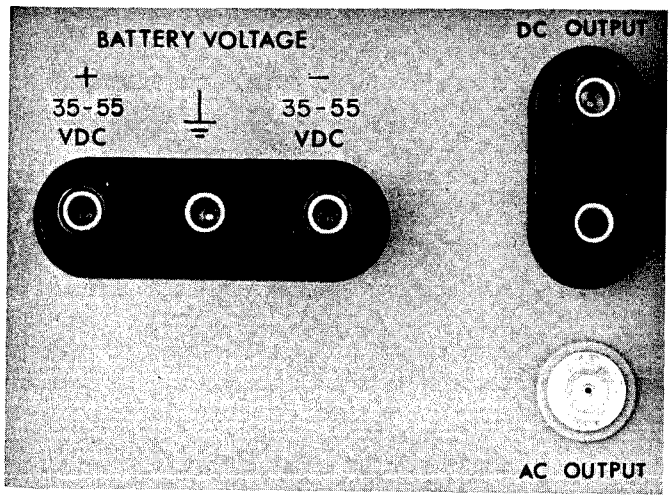

Figure 1: External Battery Terminals, DC Recorder Output Terminals and AC Amplifier Terminals

HIGH GAIN AMPLIFIER

Additionally, the 400E and 400EL provide a stable low distortion, high-gain, wideband ac amplifier with a 50-ohm output impedance. Frequency response is from 10 cps to 10 mc. The ac output is 150 mv rms for full scale meter deflection on all ranges except on the 1 mv range which is 105 mv.

LOGARITHMIC MODEL 400EL

The hp 400EL is designed for greater resolution in db measurements. This instrument is useful for acoustical and communications applications. It incorporates an hp taut-band mirror-backed logarithmic meter movement. For utmost accuracy, the meter scale is individually calibrated, using the new hp logarithmic meter calibrator. The meter scale provides maximum readability and ±1% of reading accuracy on the upper half of the scale and ±1.5% of reading accuracy on the lower half scale. The decibel scale is more than 4-3/8" long, and voltage scales spread across the full length. A range switch changes sensitivity in 10 db steps which, combined with the 12 db scale, provides the overlap desirable in decibel level measurements.

EASY TO USE

A front panel range switch which changes sensitivity in 10 db steps, combined with the db calibration of the meter, permits reading of dbm directly without calibration or conversion from —72 to +52 dbm (0 dbm=1 milliwatt into 600 ohms). In addition, the 10 db range spacing provides 2 voltage scales so that readings are always greater than one-third full scale. Consequently, the highest possible readability and accuracy are provided.

OPTIONS

Special db-measuring option—The Model 400E reads directly in volts and db, with the voltage scale uppermost. The Model 400E (Option 01.) with db scale uppermost is recommended for greater resolution in db measurements. Refer to figure 2.

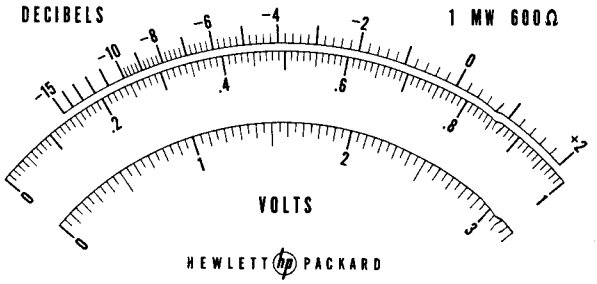

Figure 2: Meter face on Model 400E (Option 01).

Relative signal reading option—Available on special order, the 400E/EL (Option 02.) provides a front-panel relative measurement control allowing a 3 db reduction in sensitivity on each calibration range. This feature enables the user to set the meter to a convenient level (such as 0 db) for relative measurements. The control is detented in the absolute position to disconnect the relative measuring circuitry and to ensure calibration accuracy.

Constant Input Capacity Option—Available on special order, the 400E,EL (Option:03) provides constant input capacity (28 pf) on all ranges and 10 megohms input resistance.

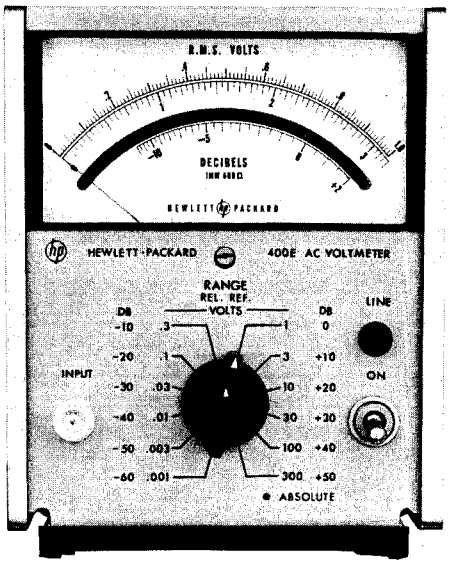

Figure 3: Option 02 (400E and EL) provides relative or absolute measurements.

SPECIFICATIONS

hp Model	400E	400EL
Voltage range	1 mv to 300 v full scale, 12 ranges	
Frequency range	10 cps to 10 mc	
Calibration	reads rms value of sine wave; voltage indication proportional to absolute average value of applied wave; db scale —10 to + 2 db, 10 db between ranges; 100 divisions on 0 to 1 scale.	reads rms value of sine wave; voltage indication proportional to absolute average value of applied wave; linear db scale —10 db to +2 db. 10 db between ranges; logarithmic voltage scales 0.3 to 1 and 0.8 to 3; 120 divisions from — 10 to +2 db.

HP MODEL 400E

ACCURACY % Of Reading

3 MV to 300 V RANGES

Frequency	*10 CPS*	*20 CPS*	*40 CPS*		*500 KC*	*1 MC*	*2 MC*	*4 MC*	*10 MC*
AT FULL SCALE	±4	±2		±1				±2	±4
AT 1/3 FULL SCALE	+4 —10	+3 —5		±3			+3 —4	+3 —5	+4 —10

ACCURACY % Of Reading

1 MV RANGE

Frequency	*10 CPS*	*20 CPS*	*40 CPS*	*100 CPS*		*100 KC*	*200 KC*	*500 KC*	*1 MC*	*2 MC*	*4 MC*	*6 MC*
AT FULL SCALE	+4 —10	±2		±1					±2	±4		+4 —10
AT 1/3 FULL SCALE	+4 —10	+3 —5		±3			+3 —4	+3 —5		+3 —10		
AT 1/10 FULL SCALE		+10 —20	+10 —15	±10		+10 —15		+10 —20	+10 —30			

SPECIFICATIONS (Cont.)

HP MODEL 400EL

ACCURACY % Of Reading

3 MV to 300 V RANGES

Frequency	10 *CPS*	20 *CPS*	40 *CPS*		500 *KC*	1 *MC*	2 *MC*	4 *MC*	10 *MC*
AT FULL SCALE	±4	±2		±1			±2	±4	
AT 1/3 FULL SCALE	+4 −10	+2 −4		±1.5		±2	+2 −4	+3 −10	

1 MV RANGE

ACCURACY % Of Reading

Frequency	10 *CPS*	20 *CPS*	40 *CPS*		200 *KC*	500 *KC*	1 *MC*	2 *MC*	4 *MC*	6 *MC*
AT FULL SCALE	+4 −10	±2		±1		±2	±4		+4 −10	
AT 1/3 FULL SCALE	+4 −10	+2 −4		±1.5	±2	+2 −4		+3 −10		

HP MODELS 400E/EL

AC-to-DC CONVERTER OUTPUT
ACCURACY % Of Reading

3 MV-300 V RANGES

Frequency	10 *CPS*	20 *CPS*	40 *CPS*	100 *CPS*		500 *KC*	1 *MC*	2 *MC*	4 *MC*	10 *MC*
AT FULL SCALE	±4	±2		±1	±0.5*		±1	±2	±4	
AT 1/3 FULL SCALE	+4 −10	+2 −4		±1			±2	+2 −4	+3 −10	

1 MV RANGE

ACCURACY % Of Reading

Frequency	10 *CPS*	20 *CPS*	40 *CPS*	100 *CPS*		100 *KC* 200 *KC*	500 *KC*	1 *MC*	2 *MC*	4 *MC*	6 *MC*
AT FULL SCALE	+4 −10	±2		±1	±0.5*	±1		±2	±4		+4 −10
AT 1/3 FULL SCALE	+4 −10	+2 −4		±1			±2	+2 −4		+3 −10	
AT 1/10 FULL SCALE		+4 −15	+4 −10	±4		+4 −10		+4 −15	+4 −30		

*For 15°C - 40°C on 1 mv - 1 volt ranges only

HP MODEL 400E/EL

Input Impedance: 10 megohms shunted by 24 pf on the 1 mv-1v ranges and 10 megohms shunted by 9 pf on the 3v-300v ranges.

Amplifier AC Output: 150 mv rms for full scale meter indication; output impedance 50 ohms, 10 cps to 10 mc (105 mv on the 1 mv range).

AC-DC Converter Output: 1 vdc output for full scale meter deflection.

Output Resistance: 1000 ohms.
Response Time: 1 second to within 1% of final value for a step change.

AC Power: 115 or 230 volts ±10%, 50 to 1000 cps, approx. 5 watts.

Temperature Range: 0 to +55°C (except where noted on accuracy charts).

External Battery Operation:
Terminals are provided on rear panel; positive and negative voltages between 35v and 55v are required; current drain from each voltage is approx. 54 ma. (External switching and on/off monitoring should be used for battery operation).

Weight: Net 6 lbs. (2,7 kg), Shipping 9 lbs. (4 kg).

Dimensions: 6-1/2" high, 5-1/8" wide, 11" deep (165,1 x 130,2 x 279,4 mm).

Price:

400E $285.00

400EL $295.00

Option: 01 (400E only) reads directly in volts and db with db scale uppermost. Add $10.00

Option: 02 (400E or 400EL) front panel relative control. Add $10.00.

Option: 03 (400E or 400EL) Constant Input capacity (10 megohms shunted by 28 pf) add $25.00

Option: 04 (400E only) includes all three options; 01, 02, and 03. Add $45.00.

Note: When ordering 2 options or less please designate each option.

Prices f.o.b. factory
Data subject to change without notice
► Indicates change from prior specifications

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SECTION I

GENERAL INFORMATION

1-1. DESCRIPTION.

1-2. The -hp- Models 400E and 400EL are versatile ac voltmeters and db meters. Both models can be used as ac to dc converters or wideband amplifiers. The Model 400E is primarily intended for voltage measurements, whereas the Model 400EL is primarily a db meter. However, both meters indicate both volts and db. The 400E has a linear ac scale with a logarithmic db scale underneath, and the 400EL has a linear db scale with a logarithmic ac scale underneath. Since the difference in scales is the only difference between the two instruments, this manual will use the term 400E/EL in reference to both instruments.

1-3. The enclosed data sheet contains a complete description of the 400E/EL along with a list of specifications.

1-4. INSTRUMENT AND MANUAL IDENTIFICATION.

1-5. Hewlett-Packard instruments are identified by a two-section, eight-digit serial number (000-00000). If the first three digits of the serial number on your instrument do not agree with those on the title page of this manual, change sheets supplied with the manual will define differences between your instrument and Model 400E/EL described in this manual.

1-6. If the first three digits of the two-section, eight-digit serial number are prefixed with an E or G, your instrument was produced in Europe. An E000-00000 serial number indicates that the instrument was manufactured in England; a G000-00000 serial number indicates that the instrument was manufactured in Germany.

SECTION II

INSTALLATION

2-1. INTRODUCTION.

2-2. This section contains information and instructions necessary for the installation and shipping of the Model 400E and 400EL voltmeters. Included are initial inspection procedures, power and grounding requirements, installation information, and instructions for repackaging for shipment.

2-3. INITIAL INSPECTION.

2-4. This instrument was carefully inspected both mechanically and electrically before shipment. It should be physically free of mars or scratches and in perfect electrical order upon receipt. To confirm this, the instrument should be inspected for physical damage in transit. Also check for supplied accessories, and test the electrical performance of the instrument using the procedure outlined in Paragraph 5-7 . If there is damage or deficiency, see the warranty on the inside front cover of this manual.

2-5. POWER REQUIREMENTS.

2-6. The Model 400E/EL can be operated from any source of 115 or 230 volts at 50 to 1000 cycles or from two 35 to 55 volt batteries connected to the rear panel BATTERY terminals. The 115/230 v slide switch on the rear panel selects the desired line voltage. Power dissipation is 5 watts maximum.

2-7. GROUNDING REQUIREMENTS.

2-8. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the instrument panel and cabinet be grounded. All Hewlett-Packard instruments are equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument. The offset pin on the power cable three-prong connector is the ground wire.

2-9. To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green pigtail on the adapter to ground.

2-10. INSTALLATION.

2-11. The Model 400E/EL is fully transistorized; therefore, no special cooling is required. However, the instrument should not be operated where the ambient temperature exceeds 55°C (131°F) or the relative humidity exceeds 95%.

2-12. BENCH MOUNTING.

2-13. The Model 400E/EL is shipped with plastic feet and tilt stand in place, ready for use as a bench instrument.

2-14. RACK MOUNTING.

2-15. The Model 400E/EL may be rack mounted by using an adapter frame (-hp- Part No. 5060-0797). The adapter frame is a rack frame that accepts any combination of submodular units. It can be rack mounted only. For additional information, address inquiries to your -hp- Sales and Service Office. (See Appendix B for office locations.)

2-16. COMBINATION MOUNTING.

2-17. The Model 400E/EL may be mounted in combination with other submodular units by using a Combining Case (-hp- Model 1051A or 1052A). The Combining Case is a full-module unit which accepts various combinations of submodular units. Being a full-module unit, it can be bench or rack mounted and is analogous to any full-module instrument.

2-18. REPACKAGING FOR SHIPMENT.

2-19. The following paragraphs contain a general guide for repackaging of the instrument for shipment. Refer to Paragraph 2-20 if the original container is to be used; 2-21 if it is not. If you have any questions, contact your local -hp- Sales and Service Office. (See Appendix B for office locations.)

NOTE

If the instrument is to be shipped to Hewlett-Packard for service or repair, attach a tag to the instrument identifying the owner and indicating the service or repair to be accomplished; include the model number and full serial number of the instrument. In any correspondence, identify the instrument by model number, serial number, and serial number prefix.

2-20. If original container is to be used, proceed as follows:

a. Place instrument in original container if available. If original container is not available, one can be purchased from your nearest -hp- Sales and Service Office.

b. Ensure that container is well sealed with strong tape or metal bands.

2-21. If original container is not to be used, proceed as follows:

a. Wrap instrument in heavy paper or plastic before placing in an inner container.

b. Place packing material around all sides of instrument and protect panel face with cardboard strips.

c. Place instrument and inner container in a heavy carton or wooden box and seal with strong tape or metal bands.

d. Mark shipping container with "DELICATE INSTRUMENT", "FRAGILE" etc.

SECTION III

OPERATING INSTRUCTIONS

3-1. INTRODUCTION.

3-2. The Model 400E/EL is primarily an ac voltmeter and db meter, but it can be used as an ac to dc converter or as a wide band amplifier.

3-3. This section explains the controls of the 400E/EL and outlines the operating procedures for each mode of operation.

3-4. LOCATION OF CONTROLS AND INDICATORS.

3-5. Figure 3-1 shows the location of each of the 400E/EL controls and explains the function of each.

3-6. OPERATING INSTRUCTIONS.

3-7. STANDARD 400E/EL.

3-8. AC Voltmeter.

NOTE

Since the 400E/EL is average responding and rms calibrated, any distortion will affect the accuracy of the measurement. Table 3-1 shows the errors caused by distortion.

Table 3-1. Effect of Distortion on Average Responding Meter

Harmonic	% Distortion	% Error (*fundamental)	
		Max. Positive	Max. Negative
Any even	0.1 0.5 1.0 2.0	0.000 0.001 0.005 0.020	
Third	0.1 0.5 1.0 2.0	0.033 0.168 0.338 0.687	0.033 0.167 0.328 0.667
Fifth	0.1 0.5 1.0 2.0	0.020 0.101 0.205 0.420	0.020 0.099 0.195 0.380

* Depends on phase relationship between harmonic and fundamental.

a. Ensure that 115-230 vac slide switch on the rear panel matches line voltage used, and connect power to the instrument. Ensure that the meter is mechanically zeroed (400E only). See Paragraph 5-5 for the zero adjustment.

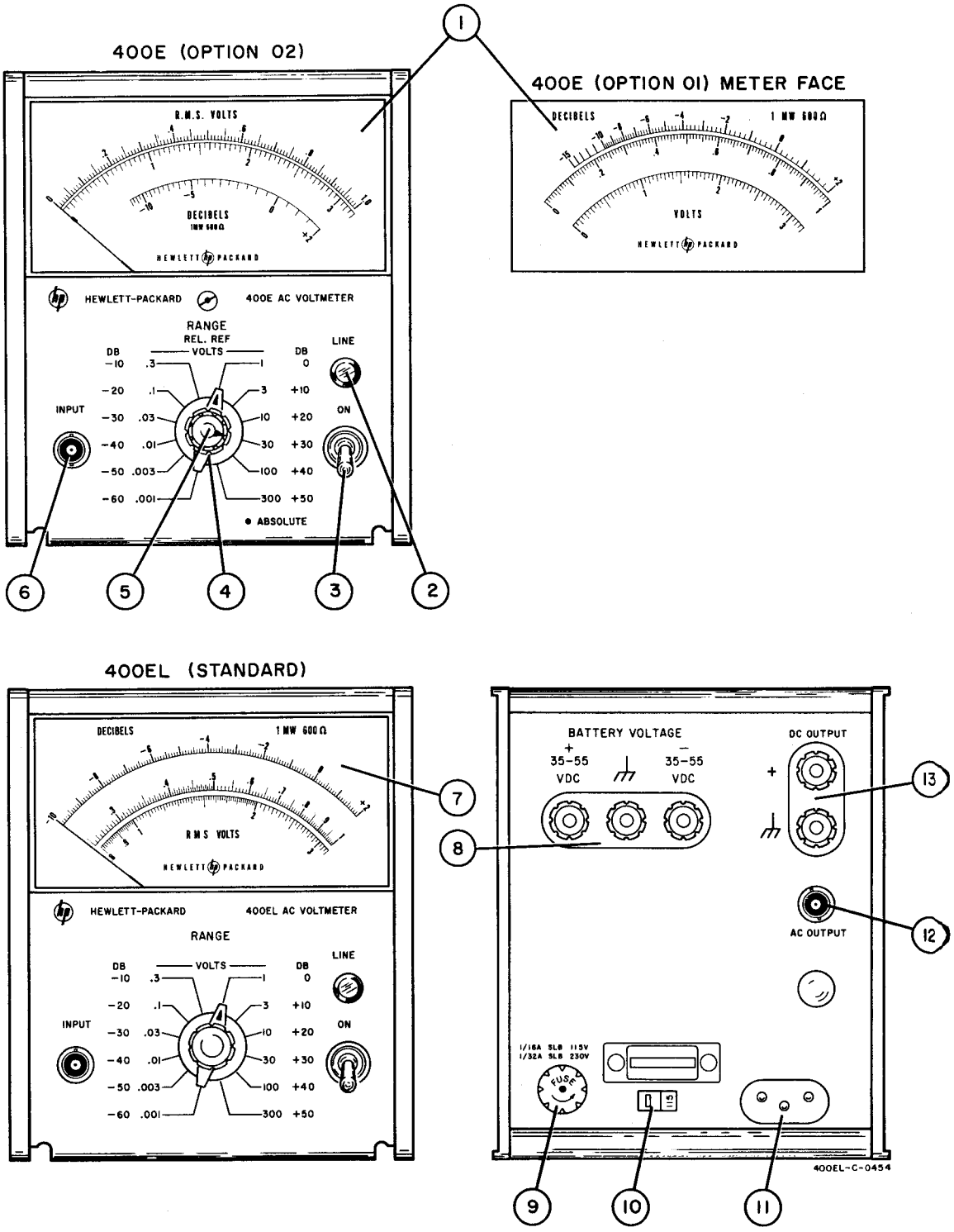


Figure 3-1. Location of Controls and Indicators

(1) 400E Scale: Indicates magnitude of applied signal in volts and dbm. Option 01 places the dbm scale uppermost for greater resolution. 0 dbm = 1 mw in 600 Ω.

(2) LINE Indicator Lamp: Indicates application of primary power.

(3) Line ON Toggle Switch: Applies primary power.

(4) RANGE Selector: Selects full scale reading of meter. Dbm reading on scale adds algebraically to DB setting of RANGE selector.

(5) REL. REF Adjust (Option 02): Lowers sensitivity of meter by 3 db. Fully clockwise ABSLOUTE position retains full meter sensitivity. This control is used to vary meter indication with a given input in order to make relative readings easier.

(6) AC INPUT: BNC input jack connects signal to be measured.

(7) 400EL Scale: Indicates magnitude of applied signal in volts and dbm. Dbm scale is linear, and voltage scales are logarithmic. This arrangement allows better resolution for db reading. 0 dbm = 1 mw in 600 Ω.

(8) BATTERY VOLTAGE Terminals: 400E/EL may be powered by connecting two 35 to 55 volt batteries to these terminals.

(9) FUSE: Protects instrument against current overload.

(10) 115/230 Volt Slide Switch: Selects 115 or 230 volts ac for line operation.

(11) PRIMARY POWER CONNECTOR: Line voltage is applied through this connector.

(12) AC OUTPUT: Ac amplifier output. Output impedance is 50 Ω.

(13) DC OUTPUT: Ac to dc converter output. Dc voltage is proportional to percentage of meter deflection. Output impedance is 1000 Ω.

Figure 3-1. Location of Controls and Indicators (Cont'd)

b. To operate the Model 400E/EL with battery power, connect two 35 to 55 volt batteries as shown in Figure 3-2. Since the front panel LINE switch has no effect during battery operation, the DPST switch in Figure 3-2 can be used as a convenient method of disconnecting the batteries when the instrument is not in use.

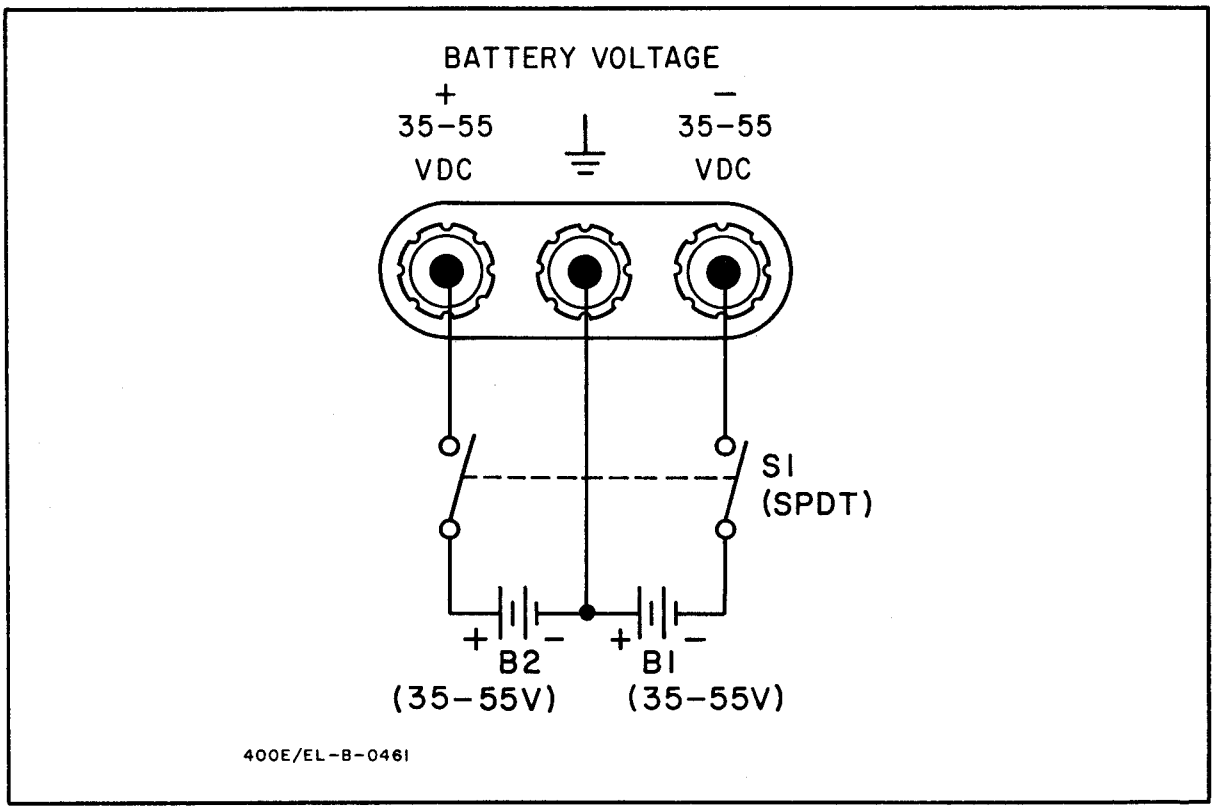


Figure 3-2. External Battery Connection

c. Turn line ON toggle switch to up position. LINE lamp will glow.

d. Select approximate range of signal to be measured.

CAUTION

DO NOT APPLY MORE THAN 600 VOLTS TO INPUT. DO NOT OVERLOAD THE 0.001 THROUGH 1 VOLT RANGES WITH MORE THAN 300 VOLTS AT FREQUENCIES BELOW 300 KC OR WITH MORE THAN 64 VOLTS AT FREQUENCIES ABOVE 300 KC. IF ANY OF THESE OVERLOADS ARE EXCEEDED, THE INSTRUMENT MAY BE DAMAGED.

e. Connect signal to be measured to INPUT terminals, and read the rms voltage on the scale.

3-9. DB Meter.

a. To make a db or dbm measurement, follow steps a through e in Paragraph 3-8, and add the scale reading to the RANGE setting. For example: If the scale reading is +1.5 and the RANGE is -30 db, the final measurement is -28.5 db.

b. The 400E/EL db scale is calibrated in dbm. 0 dbm is equivalent to 1 milliwatt dissipated by a 600 ohm load. Consequently, any dbm measurements must be made across a total impedance of 600 Ω. Measurements across other impedances will be in db, but not dbm.

c. To convert a db reading to dbm, use the Impedance Correction Graph (Figure 3-3). For example: To convert a +30 db reading made across 50 Ω to dbm, locate the load impedance on the bottom of the graph. Follow the impedance line to the heavy black line and read the meter correction at that point. The correction for 50 Ω is +10.5 dbm, and the corrected reading is +40.5 dbm.

3-10. AC to DC Converter.

a. Follow steps a through e in Paragraph 3-8.

b. Connect the rear panel DC OUTPUT terminals to a dc measuring device with a high input impedance. The dc output resistance is 1000 Ω; and if it is loaded, the dc output signal will be inaccurate.

c. The dc output is a 0 to 1 volt signal proportional to the percentage of 400E/EL meter deflection.

3-11. Wide Band AC Amplifier.

a. Follow turn-on steps a through c in Paragraph 3-8.

b. Select approximate range of input on RANGE switch.

c. Connect SIGNAL to be amplified to INPUT terminals.

d. Connect a 50 Ω amplifier load to rear panel AC OUTPUT connector.

e. The gain of the amplifier depends on the RANGE selection. On the 0.1 volt range and below, the 400E/EL amplifies the input; and on the 0.3 volt range and above, it attenuates the input. On the 0.001 volt ranges, the maximum output is 105 mv. On all other ranges, the maximum output is 150 mv. Table 3-2 shows the ac amplifier gain for each range setting.

3-12. 400E WITH OPTION 01.

3-13. Operation of the 400E with Option 01 is essentially the same as operation of the standard 400E. The db scale reads from -15 to +2 instead of from -12 to +2, and is placed at the top of the scale for better resolution.

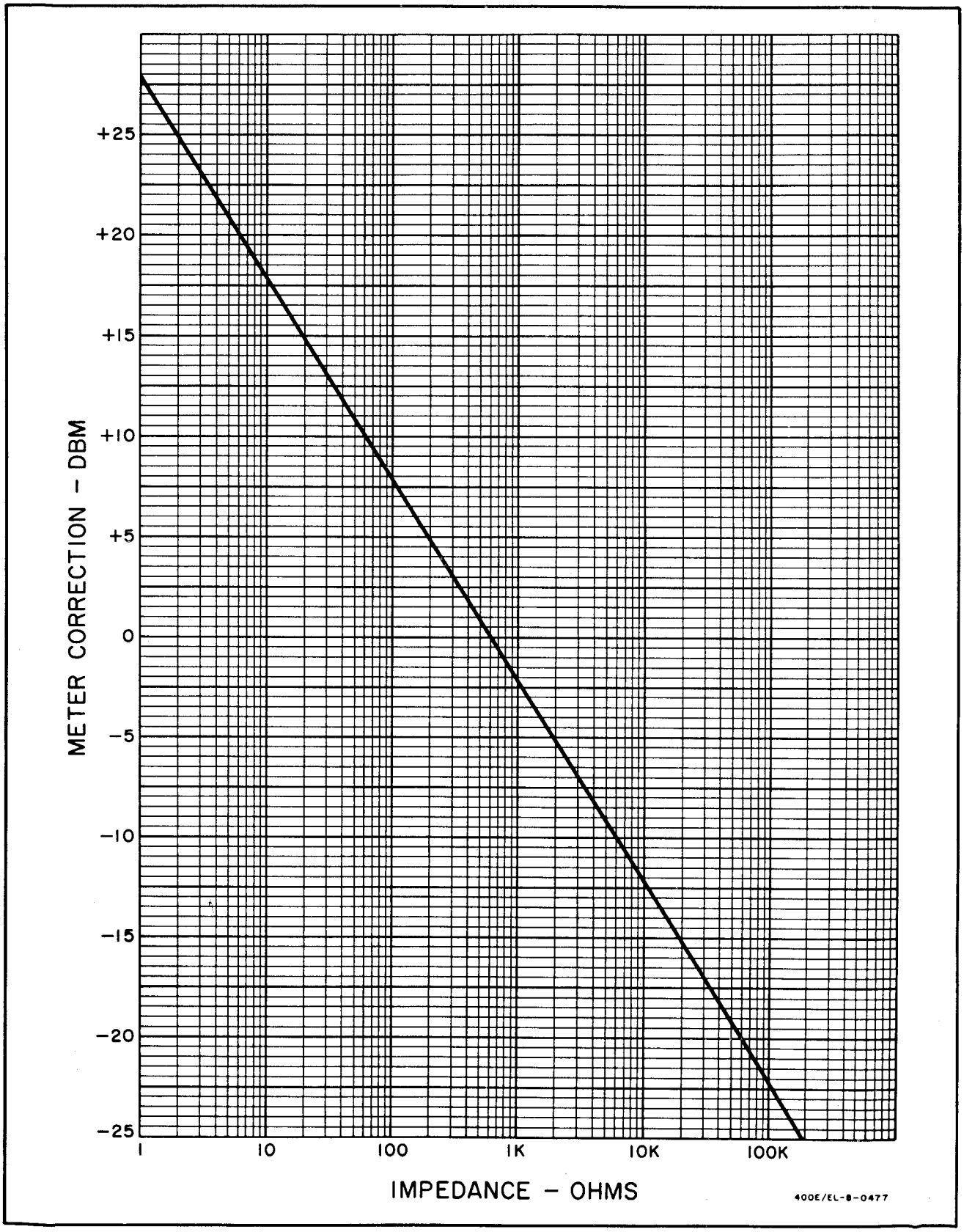


Figure 3-3. Impedance Correction Graph

Table 3-2. AC Amplifier Gain

RANGE	GAIN
0.001	+40 db
0.003	+34 db
0.01	+24 db
0.03	+14 db
0.1	+ 4 db
0.3	- 6 db

RANGE	GAIN
1	-16 db
3	-26 db
10	-36 db
30	-46 db
100	-56 db
300	-66 db

3-14. 400E/EL WITH OPTION 02.

3-15. Option 02 adds a relative reference adjustment to the 400E/EL. This adjustment allows a continuous reduction in sensitivity by 3 db. Use the REL. REF adjustment to set the meter at any convenient reference (0 db for example) in order to make relative readings easier. When the REL. REF adjustment is in the fully clockwise ABSOLUTE position, it has no effect on the meter sensitivity.

3-16. In all other respects, operation of an Option 02 instrument is the same as operation of a standard Model 400E/EL.

3-17. 400E/EL WITH OPTION 03.

3-18. An Option 03 instrument has a constant input capacity of 28 pf. Operation is the same as operation of a standard instrument.

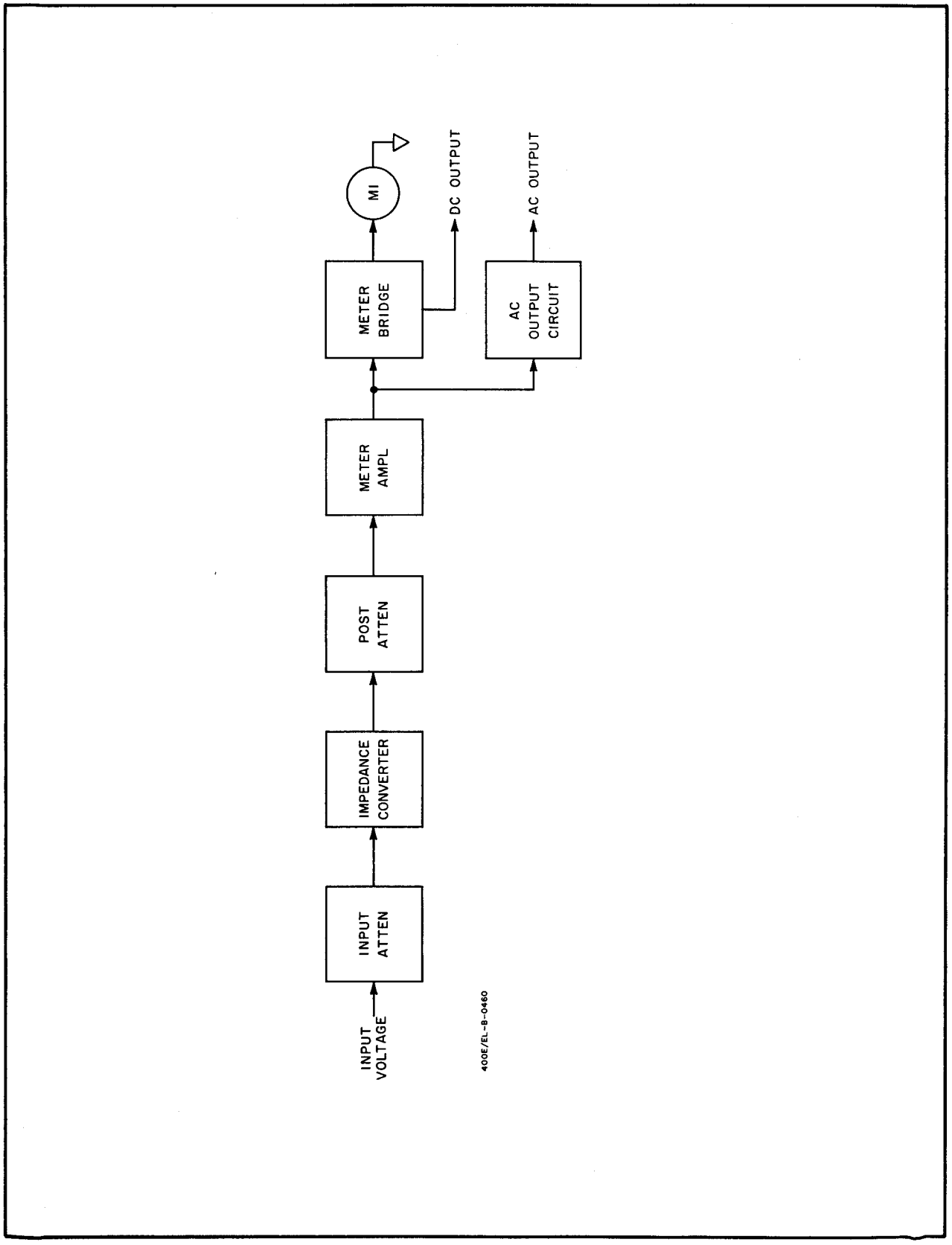


Figure 4-1. Simplified Block Diagram

SECTION IV

THEORY OF OPERATION

4-1. GENERAL.

4-2. The 400E/EL is a solid state, average responding, RMS calibrated voltmeter. It also has applications as an ac to dc converter and a wide band amplifier. Figure 4-1 shows a simplified block diagram of the instrument.

4-3. The input attenuator has two steps; the first for the 0.01 through 1 volt ranges, and the second for the 3 through 300 volt ranges. The input attenuator steps are switched by reed relays in order to isolate them. The attenuator is separately shielded.

4-4. The signal from the input attenuator is applied to the impedance converter. The impedance converter is a unity gain, feedback stabilized amplifier that matches the high impedance of the input attenuator to the much lower impedance of the post attenuator. The signal goes through the post attenuator and to the meter amplifier where it is amplified and then applied to the meter bridge.

4-5. The meter amplifier is a four-stage, high-gain amplifier utilizing both ac and dc feedback for gain stabilization. The meter bridge is in the collector circuit of the last stage of the meter amplifier. It converts the ac signal to a dc proportional to the average of the ac input. This dc drives the meter and the dc output. The instrument's ac output is the output of the meter amplifier.

4-6. INPUT ATTENUATOR (See Schematic, Figure 6-1).

4-7. The input attenuator (A1) is controlled by reed relays K1 and K2. -26 volts applied through the RANGE switch keep K1 closed when the switch is in the 0.001 through 1 volt ranges. In these positions, the input goes through the attenuator to the impedance converter with no attenuation. When the RANGE switch is in the 3 through 300 volt ranges, K2 is closed and K1 is open, and the input is attenuated by 50 db before being applied to the impedance converter.

4-8. IMPEDANCE CONVERTER.

4-9. The impedance converter, located on the main voltmeter board (A2), matches the high impedance of the input attenuator to the relatively low impedance of the post attenuator. Breakdown diodes CR17 and 18 bias diodes CR9 and CR10 at +5 and -5 volts respectively. CR9 and CR10 limit the input to 10 volts peak-to-peak, providing overload protection. Fuse F1 protects the instrument against destructive overloads.

4-10. A field-effect transistor (Q5) is used in the input stage of the impedance converter because of its characteristically high input impedance. The output is taken from the emitter circuit of Q7 and applied to the post attenuator, where it is attenuated by 10 db for each step of the RANGE Switch. The attenuated signal is then applied to the meter amplifier. The solid black lines on the schematic show the signal path, and the dotted lines show the feedback paths.

4-11. METER AMPLIFIER.

4-12. The meter amplifier amplifies its input signal by a fixed gain on all ranges except the 0.001 volt range. The amplifier itself is a four-stage amplifier with a cascode-coupled final stage (Q12 and Q13). Dc feedback is coupled from the emitter of Q12 back to the base of Q9.

4-13. The ac output from the amplifier drives the meter bridge circuit and is also fed back to the emitter of Q9. C28 in the feedback circuit adjusts the amount of feedback at the high end of the frequency range and,R38 adjusts the feedback at the low end. This way the gain of the amplifier can be set at both ends of its frequency range. R44 and R45 are switched into the feedback circuit when the RANGE switch is in the 0.001 volt position, changing the gain for that range.

4-14. METER BRIDGE.

4-15. The meter bridge rectifies the ac amplifier output and supplies the dc current to drive the meter. In order to use part of the meter bridge output as the rear terminal dc output, the meter has to be referenced to ground. Transistor Q14 references the meter to ground.

4-16. The positive alternation of the bridge input forward biases CR15, and the current flows past the base of Q14, through R53, through the meter, and to ground, forward biasing Q14. Current flows through Q14 from the positive supply, completing the loop. Thus the meter is referenced to ground, and a dc output can be taken across R65 and R2.

4-17. AC OUTPUT CIRCUIT.

4-18. The ac output circuit isolates the meter bridge and amplifier from the ac output load. It consists of two emitter followers (Q15 and Q16) connected in cascade. R59 in the base circuit of Q15 zeroes the amplifier dc output.

4-19. POWER SUPPLY.

4-20. The 400E/EL power supply produces regulated +26 volts and -26 volts. CR1 through CR4 make up a full-wave bridge rectifier whose output is regulated by two series regulator circuits. Q1 and Q2 regulate the +26 volt output,and Q3 and Q4 regulate the -26 volt output. Breakdown diode CR7 establishes the reference.

SECTION V

MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains information necessary to maintain the Model 400E/EL. The following paragraphs describe the Performance Checks, the Calibration Procedures, and the Troubleshooting Procedures.

5-3. REQUIRED EQUIPMENT.

5-4. Table 5-1 is a list of the equipment required to properly maintain the Model 400E/EL. If the model recommended in Table 5-1 is not available, a substitute may be used as long as it meets the required specifications.

5-5. MECHANICAL ZERO ADJUST (400 E Only).

5-6. Before any performance checks or calibration is begun, complete the mechanical zero adjustment in the following steps:

a. Be sure the meter has been off for at least one minute.

b. Rotate mechanical adjustment screw CLOCKWISE until meter pointer is to the left of zero and moving upscale toward zero.

c. Continue to rotate adjustment screw clockwise. STOP when needle is exactly on zero. If needle overshoots, repeat step b.

d. When pointer is exactly over zero, rotate adjustment screw about 15^{o} COUNTERCLOCKWISE to relieve tension on suspension. If the pointer moves to the left, repeat whole procedure, but make counterclockwise rotation less than 15^{o}.

5-7. PERFORMANCE CHECKS.

5-8. The performance checks are "in cabinet" tests that compare the 400E/EL with its specifications. These procedures can be used both for incoming inspection and periodic inspection.

5-9. ACCURACY AND FREQUENCY RESPONSE TEST.

5-10. The accuracy and frequency response test compares the Model 400E/EL with its accuracy specifications over the entire frequency range. For this test, a stable voltage reference and an extremely flat broad band signal generator are needed.

5-11. The test setup in Figure 5-1 uses a thermal converter with a null circuit to adjust the frequency response of the test oscillator to within 0.1% over its entire band.

NOTE

The test oscillator used must have very low distortion (<1%). A thermal converter and an average responding circuit react differently to distortion.

Table 5-1. Required Test Equipment

INSTRUMENT TYPE	REQUIRED SPECIFICATIONS	USE	RECOMMENDED MODEL
Test Oscillator	Freq. Range: 10 cps (Hz) to 10 Mc (MHz) Output: 3.0 volts rms max. Distortion: <1%	Performance Checks and Calibration	-hp- 651A Test Oscillator
DC Voltmeter	Range: 0 to 100 volts Sensitivity: 100 μvolts Accuracy: >0.1%	Performance Checks and Calibration	-hp- 3439A Digital Voltmeter with -hp- 3443A High Gain/Auto Range Unit
DC Null Meter	Range: ±3 μvolts full scale to 10 mv full scale Accuracy: 2% of full scale	Performance Checks and Calibration	-hp- 419A DC Null Meter
Thermal Converters	a. Input: 3 volts rms Output: 7 mv dc b. Input: 1 volt rms Output: 7 mv dc Accuracy: 0.02% or better Freq. Range: dc to 10 Mc (MHz)	Performance Checks and Calibration	a. -hp- 11049A b. -hp- 11050A Thermal Converters
DC Standard	Output: continuously adjustable to 3.000 vdc Accuracy: 0.1% or better	Performance Checks and Calibration	-hp- 740A DC Standard/Differential Voltmeter with 11055A output cable
0-10 MV Reference Supply	See Figure 5-1 for schematic. a. Resistor: fxd, 6500 Ω ±1% b. Resistor: var, 500 Ω ±5% 10-turn c. Resistor: var, 50 Ω ±5% 10-turn d. Battery: 1.34 volts	Performance Checks and Calibration	a. -hp- 0811-0392 b. -hp- 2100-0324 c. -hp- 2100-1481 d. Mallory RM-42R
AC-DC Voltmeter	Accuracy: ±3% Input Capacity: <5 pf Input Impedance: >10 megohms	Troubleshooting	-hp- 410C Electronic Voltmeter

Table 5-1. Required Test Equipment (Cont'd)

INSTRUMENT TYPE	REQUIRED SPECIFICATIONS	USE	RECOMMENDED MODEL
Resistors	Fxd, 100 K Ω ±1% Var, 15 K Ω ww ±5% 10-turn	Performance Checks and Calibration	-hp- 0757-0465 -hp- 2100-0896

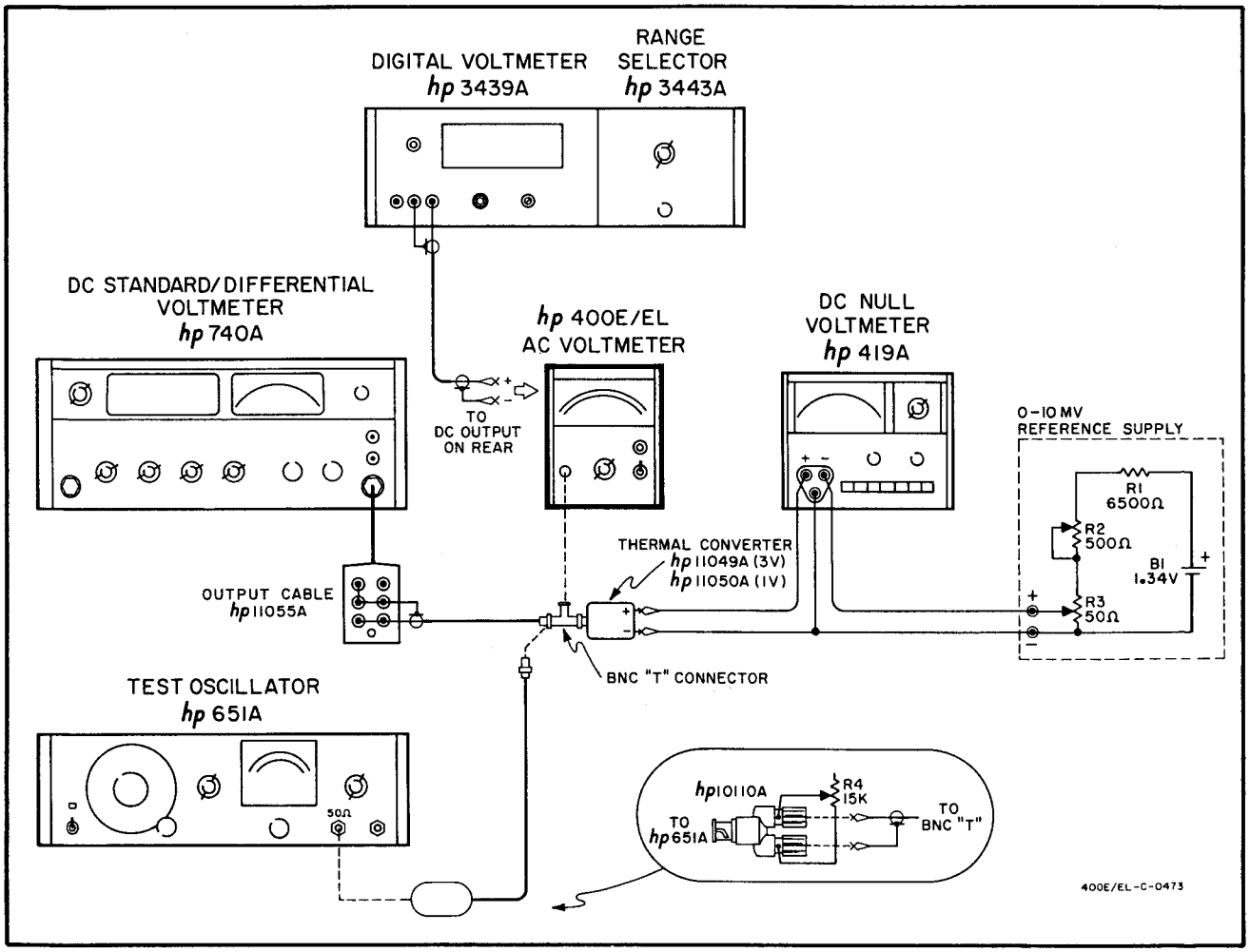


Figure 5-1. Accuracy and Frequency Response Test Setup

5-12. Reference Supply Calibration.

5-13. Use the following procedure to calibrate the thermal converter and reference supply.

a. Connect the dc standard (740A), the 400E/EL, the null voltmeter (419A), the reference supply, and a 3 volt thermal converter (11049A) as shown in Figure 5-1.

NOTE

If a 400E/EL Option 02 instrument is used, set the REL. REF adjustment to the fully clockwise ABSOLUTE position before making accuracy check.

The reference supply and the thermal converter are sensitive to variations in ambient temperature. Ensure that the ambient temperature variations are less than $\pm 2.0^{\circ}C$.

b. Set the dc standard output to +3.000 volts dc.

c. Using the null voltmeter, adjust the reference supply until it exactly nulls the thermal converter output.

d. Allow the thermal converter and the reference supply several hours to stabilize. Then readjust the reference supply to within ±1.5 microvolts of perfect null.

5-14. Model 400E/EL Accuracy Test.

5-15. Check the 400E/EL accuracy and frequency response according to the following steps.

CAUTION

SET TEST OSCILLATOR OUTPUT TO MINIMUM BEFORE CONNECTING. REDUCE OSCILLATOR OUTPUT BEFORE CHANGING FREQUENCY RANGE. DO NOT ALLOW OSCILLATOR OUTPUT TO EXCEED RATED INPUT OF THERMAL CONVERTER. ANY OVERLOAD MAY DESTROY THERMAL CONVERTER.

a. Disconnect the dc standard and immediately connect the test oscillator and the digital voltmeter as shown in Figure 5-1.

b. Set the 400E/EL Range Switch to 3 volts and set the oscillator frequency to 10 cps (Hz).

c. Using the oscillator amplitude control as coarse adjustment and resistor R4 (Figure 5-1) as fine adjustment, increase the oscillator amplitude until the thermal converter output nulls the reference supply. Observe the 400E/EL meter indication and dc output.

d. Repeat steps b and c for each frequency listed in Table 5-2. If the 400E/EL is within specifications, the meter indication and the dc output will be within the tolerances listed in Table 5-2.

e. Repeat the procedure in Paragraph 5-11 using a 1 volt thermal converter and a 1 volt output from the dc standard.

f. Repeat steps a through d in this paragraph using the one volt thermal converter. Set the 400E/EL to the 1 volt range.

5-16. Range Tracking Test.

5-17. The range tracking test checks the accuracy of the 400E/EL with a 1/3 scale input over its entire frequency range.

5-18. After verifying the full scale calibration with the accuracy test in Paragraph 5-13, check the range tracking with the following procedures.

Table 5-2. Calibration Tolerances

3 Volt Range					1 Volt Range				
Frequency	Meter Reading		DC Output		Frequency	Meter Reading		DC Output	
cps (Hz)	Min	Max	Min	Max	cps (Hz)	Min	Max	Min	Max
10	2.88	3.12	0.910	0.985	10	0.96	1.04	0.960	1.040
40	2.94	3.06	9.929	0.967	40	0.96	1.02	0.960	1.020
100	2.97	3.03	0.949	0.958	100	0.99	1.01	0.990	1.010
1000	2.97	3.03	0.949	0.958	1000	0.99	1.01	0.995	1.005
10 K	2.97	3.03	0.949	0.958	10 K	0.99	1.01	0.995	1.005
100 K	2.97	3.03	0.949	0.958	100 K	0.99	1.01	0.995	1.005
1 M	2.97	3.03	0.949	0.958	1 M	0.99	1.01	0.990	1.010
2 M	2.97	3.03	0.949	0.958	2 M	0.99	1.01	0.990	1.010
4 M	2.94	3.06	0.929	0.967	4 M	0.98	1.02	0.980	1.020
10 M	2.88	3.12	0.910	0.985	10 M	0.96	1.04	0.960	1.040

a. Connect the dc standard, 3 volt thermal converter, dc null voltmeter, and reference supply as shown in Figure 5-1.

b. Set the dc standard output to +3.000 volts dc, and adjust the reference supply output to null the thermal converter output.

CAUTION

SET TEST OSCILLATOR OUTPUT TO MINIMUM BEFORE CONNECTING. REDUCE OSCILLATOR OUTPUT BEFORE CHANGING FREQUENCY RANGE. DO NOT ALLOW OSCILLATOR OUTPUT TO EXCEED RATED INPUT OF THERMAL CONVERTER. ANY OVERLOAD MAY DESTROY THERMAL CONVERTER.

c. Disconnect the dc standard,and connect the test oscillator, the digital voltmeter, and the 400E/EL as shown in Figure 5-1.

d. Set the 400E/EL RANGE switch to 10 volts and the oscillator to 10 cps (Hz).

e. Using the oscillator amplitude control as coarse adjustment and resistor R4 as a fine adjustment, set the oscillator output so that the thermal converter output nulls the reference supply output.

f. Repeat steps b and c for each frequency listed in Table 5-3 (400E) or Table 5-4 (400EL). If the 400E/EL is within specifications, the meter indication and the dc output will be within the tolerances listed in the tables.

g. Repeat steps a through f in this paragraph using a 1 volt thermal converter and a +1.000 volt dc output from the dc standard. Set the 400E/EL to the 3 volt range.

Table 5-3. 1/3 Scale Tracking Tolerances (400E)

10 Volt Range					3 Volt Range				
Frequency	Meter Reading		DC Output		Frequency	Meter Reading		DC Output	
cps (Hz)	Min	Max	Min	Max	cps (Hz)	Min	Max	Min	Max
10	2.70	3.12	0.270	0.312	10	0.90	1.04	0.285	0.328
40	2.85	3.09	0.291	0.309	40	0.95	1.03	0.301	0.325
100	2.91	3.09	0.291	0.309	100	0.97	1.03	0.307	0.325
1000	2.91	3.09	0.291	0.309	1000	0.97	1.03	0.307	0.325
10 K	2.91	3.09	0.291	0.309	10 K	0.97	1.03	0.307	0.325
500 K	2.91	3.09	0.291	0.309	500 K	0.97	1.03	0.307	0.325
1 M	2.88	3.09	0.288	0.309	1 M	0.96	1.03	0.304	0.325
4 M	2.85	3.09	0.285	0.309	4 M	0.95	1.03	0.301	0.325
10 M	2.70	3.12	0.270	0.312	10 M	0.90	1.04	0.285	0.328

Table 5-4. 1/3 Scale Tracking Tolerances (400EL)

10 Volt Range					3 Volt Range				
Frequency	Meter Reading		DC Output		Frequency	Meter Reading		DC Output	
cps (Hz)	Min	Max	Min	Max	cps (Hz)	Min	Max	Min	Max
10	2.70	3.12	0.270	0.312	10	0.90	1.04	0.284	0.304
40	2.96	3.04	0.297	0.303	40	0.98	1.02	0.311	0.321
100	2.96	3.04	0.297	0.303	100	0.98	1.02	0.311	0.321
1000	2.96	3.04	0.297	0.303	1000	0.98	1.02	0.311	0.321
10 K	2.96	3.04	0.297	0.303	10 K	0.98	1.02	0.311	0.321
500 K	2.94	3.06	0.294	0.306	500 K	0.98	1.02	0.311	0.321
1 M	2.94	3.06	0.294	0.306	1 M	0.98	1.02	0.310	0.322
4 M	2.88	3.06	0.288	0.306	4 M	0.96	1.02	0.304	0.322
10 M	2.70	3.07	0.270	0.309	10 M	0.90	1.03	0.284	0.325

5-19. INPUT IMPEDANCE CHECK.

5-20. Input Resistance Check.

a. Connect the 50 Ω output of the test oscillator to the input of the 400E/EL.

b. Set the test oscillator and the 400E/EL to the 3 volt range. Set the oscillator output to 40 cps (Hz) and adjust the output for a full scale indication as shown.

c. Connect a 100 K Ω resistor between the test oscillator output and the 400E/EL input as shown in Figure 5-2.

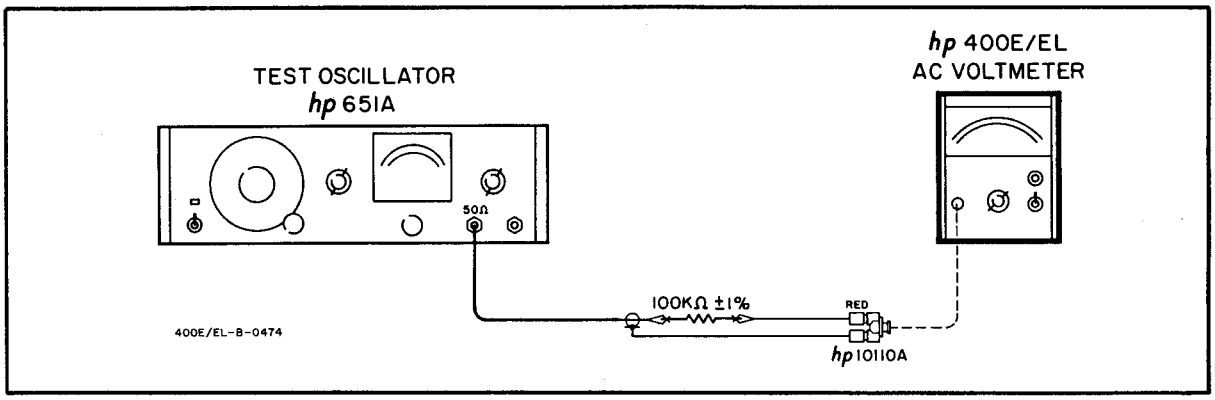


Figure 5-2. Input Impedance Check

d. The 400E/EL indication should not drop more than one small scale division from full scale. This verifies an input resistance of 10 M Ω.

5-21. Input Capacity Check (Option 01, 02, and Standard 400E/EL).

a. Connect a test oscillator, a 100 K Ω resistor, and the 400E/EL as shown in Figure 5-2.

b. With the 400E/EL on the 3 volt range, adjust the test oscillator for a full scale reading on the 400E/EL at 400 cps (Hz).

c. Increase the test oscillator frequency until the 400E/EL indication drops to 2.12 volts. This should occur at a frequency of 105 Kc (KHz) or greater, verifying an input capacity of 9 pf or less on the 3 volt range.

d. Repeat steps a and b with the 400E/EL on the 1 volt range.

e. Increase the test oscillator frequency until the 400E/EL indication drops to 0.707 volts. This should occur at a frequency of 55 Kc (KHz) or greater, verifying an input capacity of 24 pf or less on the 1 volt range.

5-22. Input Capacity (Option 03 Only).

5-23. Repeat the steps in Paragraph 5-21. On both ranges, the signal should drop to the proper level at a frequency of 50 Kc (KHz) or greater. This verifies an input capacity of 28 pf or less on all ranges.

5-24. ALIGNMENT AND CALIBRATION PROCEDURE.

5-25. The calibration adjustments are "cover off" procedures to adjust the 400E/EL to its performance specifications. If the instrument cannot be properly adjusted, refer to the Troubleshooting Procedures (Paragraph 5-36). Figure 5-3 shows the location of all the internal adjustments.

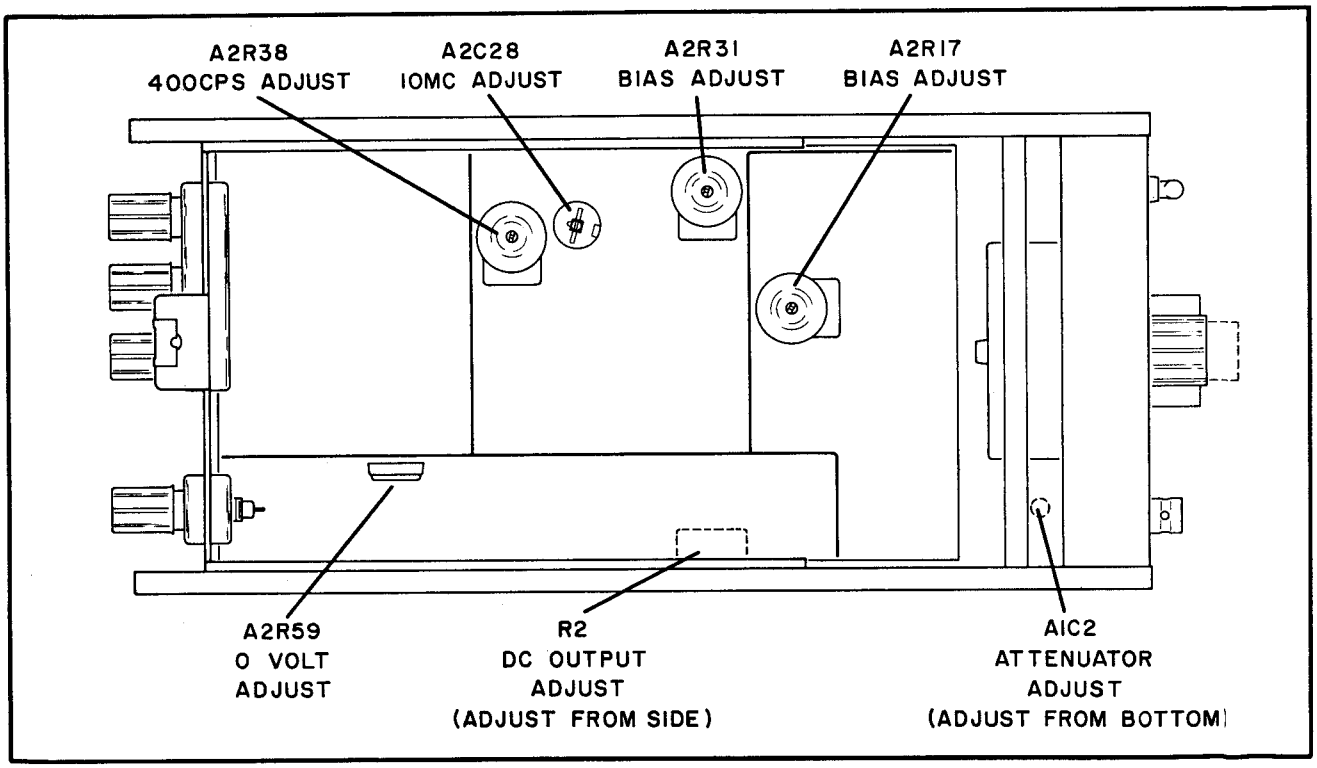


Figure 5-3. Location of Internal Adjustments

5-26. COVER REMOVAL.

5-27. To remove the top or bottom covers, remove the Phillips screw at the rear of the cover; and if the instrument has a handle, remove the screw under the handle. Slide the cover about 1 inch to the rear, and lift it off. To replace the cover, reverse the removal procedure.

5-28. To remove a side cover, remove the four Phillips screws and lift if off.

5-29. BIAS ADJUST.

5-30. Connect a dc voltmeter (410C) to TP3 and adjust A2R17 for -6.0 ±0.25 vdc. Connect a dc voltmeter to TP4 and adjust A2R31 for +10.0 ±0.5 vdc.

5-31. AC OUTPUT ZERO.

5-32. Connect a dc voltmeter (410C) to TP5 and adjust A2R59 for 0.0 ±0.050 vdc.

5-33. CALIBRATION.

NOTE

If a 400E/EL Option 02 is to be calibrated, set the REL. REF adjustment to the fully clockwise ABSOLUTE position before beginning the calibration.

5-34. Attenuator Alignment.

a. Use the setup shown in Figure 5-1 to align the attenuator. Calibrate the reference supply according to the procedures in Paragraph 5-10 using a 3 volt thermal converter.

CAUTION

SET TEST OSCILLATOR OUTPUT TO MINIMUM BEFORE CONNECTING. REDUCE OSCILLATOR OUTPUT BEFORE CHANGING FREQUENCY RANGE. DO NOT ALLOW OSCILLATOR OUTPUT TO EXCEED RATED INPUT OF THERMAL CONVERTER. ANY OVERLOAD MAY DESTROY THERMAL CONVERTER.

b. Disconnect the dc standard and connect the test oscillator and 400E/EL as shown in Figure 5-1. Set the oscillator frequency to 100 Kc (KHz) and the 400E/EL to the 3 volt range. Using the amplitude control as coarse adjustment and R4 as fine adjustment, increase the oscillator output until the thermal converter output nulls the reference supply.

c. Adjust A1C1 in the 400E/EL for a meter reading of 3.00 volts.

5-35. Low and High Frequency Calibration.

a. Calibrate the reference supply in Figure 5-1 with a 1 volt thermal converter according to the steps in Paragraph 5-10.

b. Disconnect the dc standard and connect the test oscillator, the 400E/EL, and the digital voltmeter as shown in Figure 5-1. Set the oscillator frequency to 400 cps (Hz) and the 400E/EL to the 1 volt range. Using the amplitude control as coarse adjustment and R4 as fine adjustment, increase the oscillator output until the thermal converter output nulls the reference supply.

c. Adjust A2R38 for a 400E/EL meter reading of 1.00 ±0.01 volts.

d. Adjust R2 for a digital voltmeter display of 1.000 ±0.005 vdc.

e. Lower test oscillator output and set frequency to 10 Mc (MHz). Readjust oscillator amplitude until thermal converter output nulls reference supply.

f. Adjust A2C28 for digital voltmeter display of 1.000 ±0.04.

5-36. TROUBLESHOOTING.

5-37. When the 400E/EL operates improperly, either it is adjusted improperly or a circuit is malfunctioning. Before troubleshooting the instrument, adjust and calibrate it according to the procedures in Paragraph 5-22. If calibration is impossible, proceed with the troubleshooting steps.

5-38. Check the instrument for any obvious evidence of trouble, such as loose or broken wires or broken connectors. Check the printed circuit boards for separations or cracks and ensure that all pins are clean.

5-39. First isolate the trouble to a particular circuit using the block diagram (Figure 4-1) and the schematic (Figure 6-1). Table 5-5 lists some likely troubles and their probable causes. Then refer to the troubleshooting steps for that circuit.

NOTE

The test voltages shown in this section are nominal. A tolerance of ±5% is allowable.

Table 5-5. Troubleshooting Guide

SYMPTOM	PROBABLE TROUBLE
No response to input.	Fuse A2F1 open.
Instrument will not uprange above 1 volt, but works on 1 volt range and below.	Relay K1 stuck closed.
Instrument will not downrange below 3 v, but works on 3 v range and above.	Relay K2 stuck closed.
TP3 voltage cannot be properly adjusted.	Impedance Converter (A2Q5, 6, and 7).
TP5 voltage cannot be properly adjusted.	Ac output circuit (A2Q15, 16).
TP4 voltage cannot be properly adjusted.	Meter amplifier (A2Q8 - 13).

5-40. POWER SUPPLY.

5-41. Check with a dc voltmeter (410C) at TP1 and TP2 for +26 volts and -26 volts respectively. If the TP voltages are improper, check the voltages listed

in Table 5-6. If the voltage for a given component is wrong, the trouble is probably in that component or its associated circuit.

Table 5-6. Power Supply Voltages

COMPONENT	VOLTAGE
Collector Q1	+39 v
Collector Q2	+26.5 v
Emitter Q2	+ 6.98 v
Base Q3	- 0.6 v
Collector Q3	-23.5 v
Collector Q4	-39 v

5-42. AMPLIFIERS.

5-43. Both the impedance converter and the meter amplifier are internally dc coupled. If the dc voltages anywhere in the amplifier are incorrect, the amplifier won't operate properly. Consequently a check of the dc voltages is a good check of the amplifiers.

5-44. Tables 5-7 and 5-8 contain the dc voltages on all of the transistors in the meter amplifier and the impedance converter. If the measured voltage on a given transistor is wrong, the trouble is probably in that transistor or its associated circuit.

NOTE

Measure these dc voltages with the input shorted. A dc voltmeter with low input capacitance and very high input resistance must be used. The -hp- 410C is recommended.

Table 5-7. Impedance Converter Voltages

TRANSISTOR	E	B	C
Q5	(S) - 6 v	(D) *	(D) 14.4 v
Q6	-15 v	-14.3 v	- 7.4 v
Q7	- 6.7 v	- 7.4 v	-21.5 v

* Cannot be measured.

Table 5-8. Meter Amplifier Voltages

TRANSISTOR	E	B	C
Q8	+22.25 v	+23 v	+25.5 v
Q9	+ 0.02 v	+ 0.57 v	+ 7.5 v
Q10	+ 8.2 v	+ 7.5 v	+ 1.8 v
Q11	+ 1.25 v	+ 1.8 v	+ 8 v
Q12	+ 9 v	+ 8 v	+ 0.27 v
Q13	+ 0.27 v	0 v	- 6.2 v
Q14*	- 0.45 v	+ 0.02 v	+26 v

* In bridge circuit.

5-45. AC OUTPUT CIRCUIT.

5-46. To check the ac output circuit, measure the dc voltages at the points shown in Table 5-9. If a given measured voltage is incorrect, the trouble is probably in that component or its associated circuit.

Table 5-9. AC Voltage Output Circuit

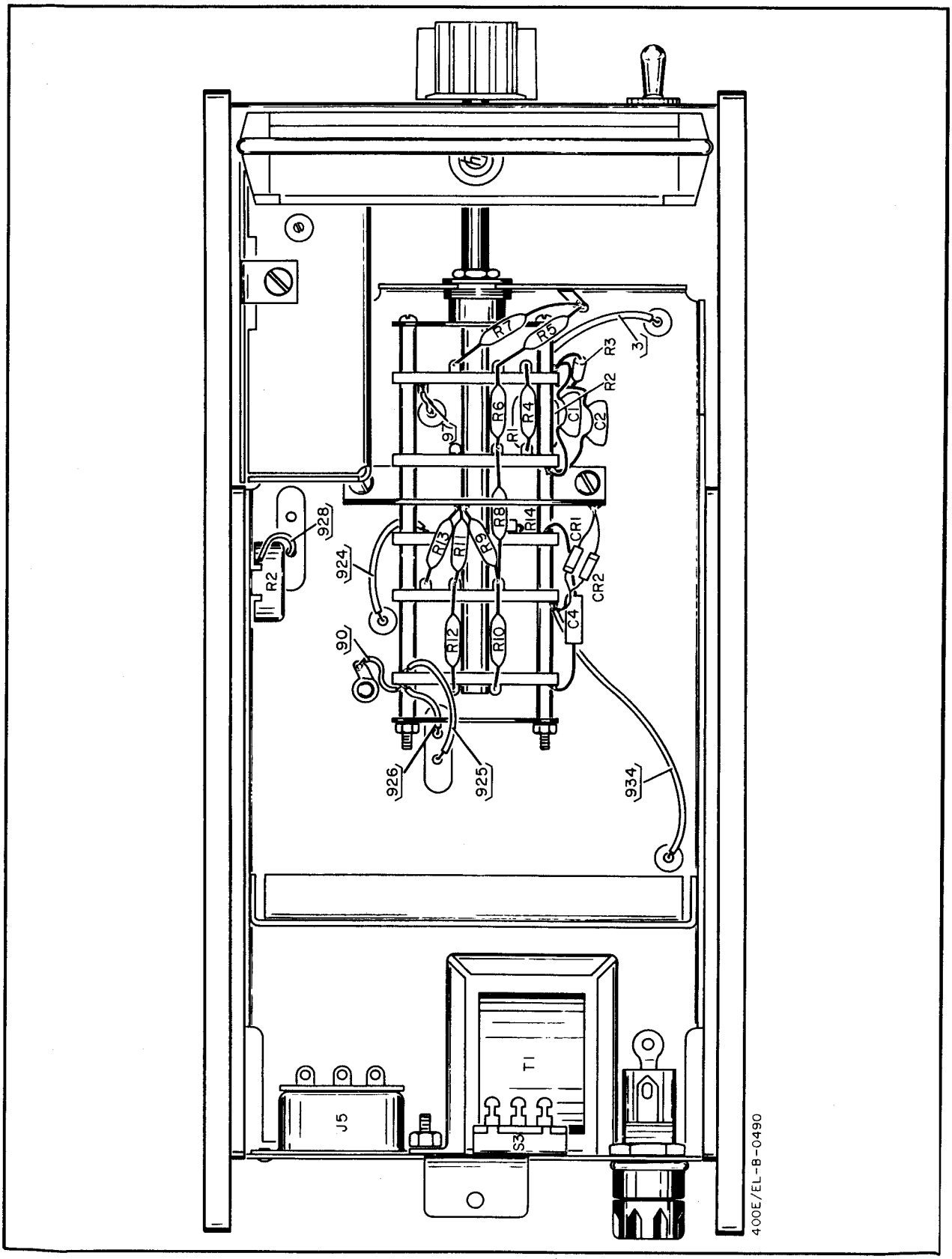
TRANSISTOR	E	B	C
Q15	+0.68 v	+1.3 v	+4.6 v
Q16	0 v	+0.66 v	+4.6 v

SECTION VI

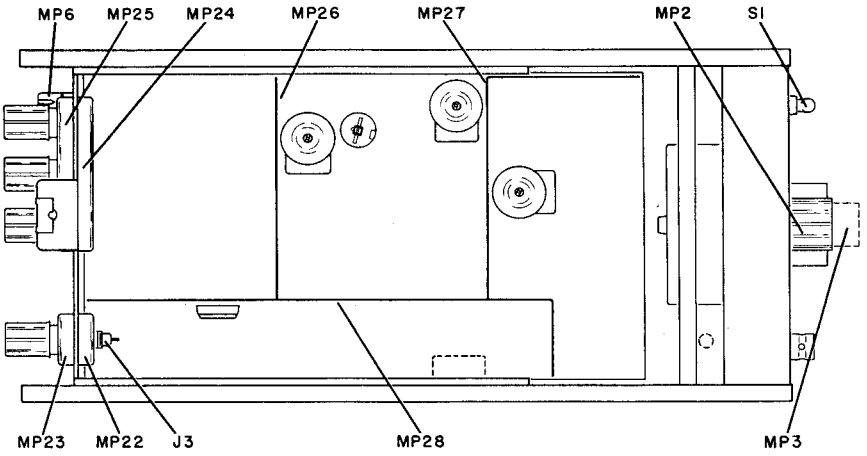
CIRCUIT DIAGRAMS

6-1. INTRODUCTION.

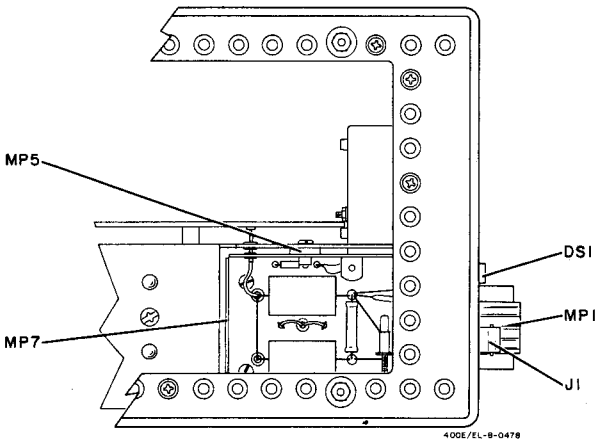
6-2. This section contains the circuit diagrams necessary for maintenance of the Model 400E/EL. A schematic, a component location drawing, and a diagram of the RANGE switch are included. Location grids are drawn on the more complicated diagrams making the search for individual components easier.


R7
R5
R3
3
R2
R6
R4
C1
C2
R1
97
928
R8
R14
CR1
R13
R11
R9
924
CR2
R2
C4
90
R12
R10
926
925
934
J5
T1
S3
400E/EL-B-0490

p/o Figure 6-1



TOP VIEW



LEFT SIDE VIEW

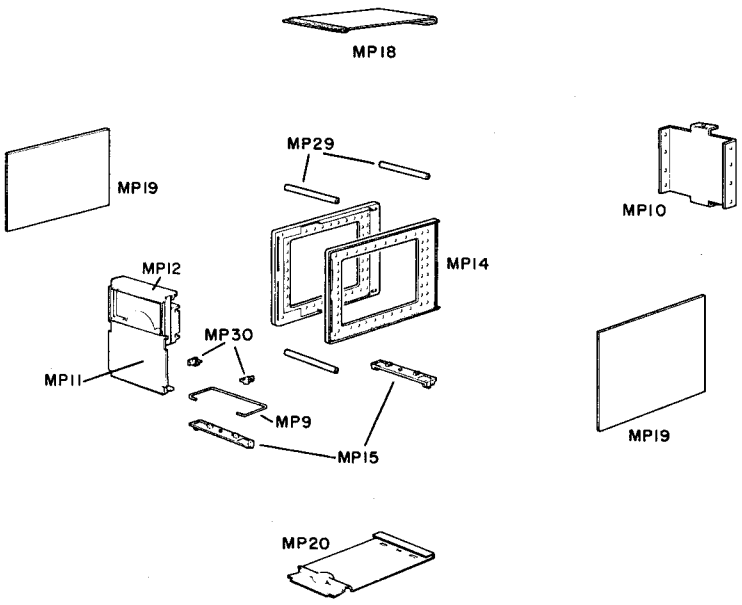


Figure 7-1. Location of Important Mechanical Parts

SECTION VII
REPLACEABLE PARTS

7-1. INTRODUCTION.

7-2. This section contains information for ordering replacement parts. Table 7-1 lists parts in alphameric order of their reference designators and indicates the description and -hp- part number of each part, together with any applicable notes. Table 7-2 lists parts in alphameric order of their -hp- part number and provides the following information on each part:

a. Description of the part. (See list of abbreviations below.)

b. Typical manufacturer of the part in a five-digit code. (See Appendix A for list of manufacturers.)

c. Manufacturer's part number.

d. Total quantity used in the instrument (TQ column).

7-3. Miscellaneous parts are listed at the end of Table 7-1.

7-4. ORDERING INFORMATION.

7-5. To obtain replacement parts, address order or inquiry to your local Hewlett-Packard Field Office. (See Appendix B for list of office locations.) Identify parts by their Hewlett-Packard part numbers.

7-6. NON-LISTED PARTS.

7-7. To obtain a part that is not listed, include:

a. Instrument model number.

b. Instrument serial number.

c. Description of the part.

d. Function and location of the part.

DESIGNATORS

A	= assembly	F	= fuse	P	= plug	V	= vacuum tube, neon bulb, photocell etc.
B	= motor	FL	= filter	Q	= transistor		
BT	= battery	HR	= heater	QCR	= transistor-diode	W	= cable
C	= capacitor	J	= jack	R	= resistor	X	= socket
CR	= diode	K	= relay	RT	= thermistor	XDS	= lampholder
DL	= delay line	L	= inductor	S	= switch	XF	= fuseholder
DS	= lamp	M	= meter	T	= transformer		
E	= misc electronic part	MP	= mechanical part	TC	= thermocouple	Z	= network

ABBREVIATIONS

Ag	= silver	ID	= inside diameter	ns	= nanosecond (s) = 10^{-9}	SPDT	= single-pole double-throw
Al	= aluminum	impg	= impregnated	nsr	= not separately replaceable	SPST	= single-pole single-throw
amp	= ampere (s)	incd	= incandescent				
Au	= gold	ins	= insulation (ed)				
				obd	= order by description	Ta	= tantalum
C	= capacitor	K	= kilohm (s) = 10^{+3}	OD	= outside diameter	TiO_2	= titanium dioxide
cer	= ceramic	Kc	= kiloycycle (s) = 10^{+3}			tog	= toggle
coef	= coefficient			p	= peak	tol	= tolerance
com	= common	L	= inductor	pc	= printed circuit	trim	= trimmer
comp	= composition	lin	= linear taper	pf	= picofarad (s) = 10^{-12}	TSTR	= transistor
conn	= connection	log	= logarithmic taper	piv	= peak inverse voltage		
cps	= cycles per second			p/o	= part of	v	= volt (s)
		m	= milli = 10^{-3}	pos	= position (s)	vacw	= alternating current working volt (s)
dep	= deposited	ma	= milliampere (s) = 10^{-3}	poly	= polystyrene		
DPDT	= double-pole double-throw	Mc	= megacycle (s) = 10^{+6}	pot	= potentiometer	var	= variable
		meg	= megohm (s) = 10^{+6}	p-p	= peak-to-peak	vdcw	= direct current working volt (s)
DPST	= double-pole single-throw	met flm	= metal film	prec	= precision (temperature coefficient, long term stability, and/or tolerance)		
		mfr	= manufacturer			w	= watt (s)
elect	= electrolytic	mtg	= mounting			w/	= with
encap	= encapsulated	μ	= micro = 10^{-6}			wiv	= reverse working voltage
		my	= Mylar ®	R	= resistor	w/o	= without
f	= farad (s)			Rh	= rhodium	ww	= wirewound
FET	= field effect transistor	na	= nanoampere (s) = 10^{-9}	rms	= root-mean-square		
fxd	= fixed	NC	= normally closed	rot	= rotary	*	= optimum value selected at factory, **average** value shown (**part** may be omitted)
GaAs	= gallium arsenide	Ne	= neon				
Gc	= gigacycle (s) = 10^{+9}	NO	= normally open	Se	= selenium	**	= no standard type number assigned (selected or special type)
gd	= guard (ed)	NPO	= negative positive zero (zero temperature coefficient)	sect	= section (s)		
Ge	= germanium			Si	= silicon		
grd	= ground (ed)			sl	= slide		
h	= henry (ies)	® Dupont de Nemours					
Hg	= mercury						

Table 7-1. Reference Designation Index

REFERENCE DESIGNATION	-hp- PART NO.	DESCRIPTION	NOTE
A1	00400-66502	Board: etched circuit assembly input attenuator includes: A1C1 thru A1C6 A1R1 thru A1R4 A1K2 A and B	
A1C1	0150-0098	C: cer disc .01 μf ±20% 1000 vdcw	
A1C2	0132-0003	C: var trimmer 0.7 - 3 pf terminal spacing 0 degree	
A1C3	0140-0149	C: fxd mica 470 pf ±5%	
A1C4	0140-0198	C: fxd mica 200 pf ±5%	
A1C5 and A1C6	0150-0093	C: fxd cer durez coated disc 0.01μf +80% -20% 100 vdcw	
A1R1	0683-1005	R: fxd comp 10 ohm ±5% 1/4 w	
A1R2	0698-4128	R: fxd prec met flm 10.0 meg ±.25% 1/2 w	
A1R3	0698-4129	R: fxd prec met flm 31.723 K ±.1% 1/2 w	
A1R4	0757-0391	R: fxd prec met flm 39.2 ohm ±1% 1/8 w	
A1K2	00400-10500	Relay: reed Form A	
A1K2	00400-10499	Relay: reed Form B	
A2	00400-66501	Board Assembly A2C1 thru A2C43 A2CR1 thru A2CR19 A2Q1 thru A2Q19 A2R1 thru A2R70	
A2C1 and A2C2	0180-0149	C: fxd Al elect 65 μf +100% -10% 60 vdcw	
A2C3	0150-0050	C: fxd cer disc 1000 pf GMV 600 vdcw	
A2C4	0180-0142	C: fxd Al elect 20 μf +100% -10% 25 vdcw	
A2C5	0180-0061	C: fxd elect 100 μf +100% -10% 15 vdcw	
A2C6	0180-0155	C: fxd Ta elect 2.2 μf ±20% 20 vdcw	
A2C7	0180-0142	C: fxd Al elect 20 μf +100% -10% 25 vdcw	
A2C8 and A2C9	0180-0101	C: fxd Ta 1.8 μf ±20% 35 vdcw	
A2C10	0150-0084	C: fxd cer .1 μf +80% -20% 50 vdcw	
A2C11	0180-0064	C: fxd elect 35 μf +100% -10% 6 vdcw	
A2C12	0140-0194	C: fxd mica 110 pf ±5%	
A2C13	0180-0137	C: fxd Ta elect 100 μf ±20% 10 vdcw	
A2C14	0180-0059	C: fxd elect 10 μf +100% -10% 25 vdcw	
A2C15	0140-0145	C: fxd mica 22 pf ±5%	
A2C16	0150-0093	C: fxd cer durez coated disc 0.01μf+80% -20% 100 vdcw	
A3C17	0180-1780	C: fxd Al elect 500 μf +75% -10% 10 vdcw	
A2C18	0180-0101	C: fxd Ta 1.8 μf ±10% 35 vdcw	
A2C19	0150-0093	C: fxd cer durez coated disc 0.01μf+80% -20% 100 vdcw	
A2C20	0180-1793	C: fxd 450 mfd +30% -10%	
A2C21	0150-0093	C: fxd cer durez coated disc 0.01μf+80% -20% 10 vdcw	
A2C22	0180-0100	C: fxd Ta 4.7 μf ±10% 35 vdcw	
A2C23	0140-0198	C: fxd mica 200 pf ±5%	
A2C24	0140-0203	C: fxd mica 30 pf ±5%	
A2C25	0150-0015	C: fxd TiO_2 2.2 pf ±10% 500 vdcw	
A2C26	0150-0093	C: fxd cer durez coated disc 0.01μf+80% -20% 100 vdcw	
A2C27		Not Assigned	
A2C28	0130-0016	C: var cer 5 - 25 pf	
A2C29	0180-0100	C: fxd Ta 4.7 μf ±10% 35 vdcw	
A2C30	0140-0202	C: fxd mica 15 pf ±5%	

Table 7-1. Reference Designation Index (Cont'd)

REFERENCE DESIGNATION	-hp- PART NO.	DESCRIPTION	NOTE
A2C31	0180-1794	C: fxd Ta elect 22 μf 35 vdcw	
A2C32	0140-0190	C: fxd mica 39 pf ±5%	
A2C33	0180-1779	C: fxd Ta elect 18 μf 35 vdcw	
A2C34	0180-0354	C: fxd Ta elect 40 μf ±5% 10 vdcw	
A2C35	0150-0093	C: fxd cer durez coated disc 0.01 μf +80% -20% 100 vdcw	
A2C36	0180-0354	C: fxd Ta elect 40 μf ±5% 10 vdcw	
A2C37	0180-0137	C: fxd Ta elect 100 μf ±20% 10 vdcw	
A2C38	0180-0100	C: fxd Ta 4.7 μf ±10% 35 vdcw	
A2C39	0180-0155	C: fxd Ta elect 2.2 μf ±20% 20 vdcw	
A2C40	0180-0064	C: fxd elect 35 μf +100% -10% 6 vdcw	
A2C41	0180-0100	C: fxd Ta 4.7 μf ±10% 35 vdcw	
A2C42 and A2C43	0150-0122	C: fxd cer 2000 pf ±20% 500 vdcw	
A2CR1 thru A2CR6	1901-0033	CR: Si 100 ma at +1 v 180 wiv 13 pf	
A2CR7	1902-3125	CR: Si breakdown 6.98 v ±2% 400 mw	
A2CR8	1901-0025	CR: Si 100 ma +1 v 100 piv 12 pf	
A2CR9 and A2CR10	1901-0044	CR: Si 20 ma +1 v 10 na -10 v 50 wiv 2 pf 6 ns	
A2CR11	1901-0025	CR: Si 100 ma +1 v 100 piv 12 pf	
A2CR12	1902-3222	CR: Si breakdown 17.4 v ±5% 400 mw	
A2CR13	1902-0182	CR: breakdown 20.5 v ±5% 400 mw	
A2CR14	1902-3179	CR: Si breakdown 11.8 v ±5% 400 mw	
A2CR15 and A2CR16	1901-0456	CR: Si 35 ma 20 BV 1.2 pf	
A2CR17 and A2CR18	1901-3090	CR:	
A2CR19	1902-0031	CR: breakdown 12.7 v ±5% 400 mw	
A2Q1	1854-0039	Q: Si NPN 2N3053	
A2Q2	1854-0033	Q: Si NPN 2N3391	
A2Q3	1853-0016	Q: Si PNP 2N3638	
A2Q4	1850-0064	Q: Ge PNP 2N183	
A2Q5	1855-0016	Q: FET P Channel	
A2Q6	1854-0073	Q: Si NPN 2N3478	
A2Q7	1853-0009	Q: Si PNP **	
A2Q8	1854-0033	Q: Si NPN 2N3391	
A2Q9	1854-0042	Q: Si NPN **	
A2Q10	1853-0009	Q: Si PNP **	
A2Q11	1854-0073	Q: Si NPN 2N3478	
A2Q12	1853-0010	Q: Si PNP **	
A2Q13	1850-0158	Q: Ge PNP 2N2635	
A2Q14 thru A2Q16	1854-0057	Q: Si NPN **	
A2R1	0757-0794	R: fxd prec met flm 68.1 ohm ±1% 1/2 w	
A2R2 and A2R3	0683-2025	R: fxd comp 2000 ohm ±5% 1/4 w	
A2R4	0683-6825	R: fxd comp 6800 ohm ±5% 1/4 w	
A2R5	0698-4121	R: fxd prec met flm 11.3 K ±1% 1/8 w	

Table 7-1. Reference Designation Index (Cont'd)

REFERENCE DESIGNATION	-hp- PART NO.	DESCRIPTION	NOTE
A2R6	0698-3155	R: fxd prec met flm 4640 ohm ±1% 1/8 w	
A2R7 and A2R8	0683-2025	R: fxd comp 2000 ohm ±5% 1/4 w	
A2R9	0757-0794	R: fxd prec met flm 68.1 ohm ±1% 1/2 w	
A2R10	0757-0447	R: fxd prec met flm 16.2 K ±1% 1/8 w	
A2R11	0698-3156	R: fxd prec met flm 14.7 K ±1% 1/8 w	
A2R12		Not Assigned	
A2R13		Not Assigned	
A2R14		Not Assigned	
A2R15	0757-0808	R: fxd prec met flm 301 ohm ±1% 1/2 w	
A2R16	0683-8235	R: fxd comp 82 K ±5% 1/4 w	
A2R17	2100-0093	R: var comp pot lin 20 K ±20% 0.10 w	
A2R18	0683-4735	R: fxd comp 47 K ±5% 1/4 w	
A2R19	0686-2265	R: fxd comp 22 meg ±5% 1/2 w	
A2R20	0684-1001	R: fxd comp 10 ohm ±10% 1/4 w	
A2R21	0757-0824	R: fxd prec met flm 2000 ohm ±1% 1/2 w	
A2R22	0757-0416	R: fxd prec met flm 511 ohm ±1% 1/8 w	
A2R23 and A2R24	0757-0434	R: fxd prec met flm 3650 K ±1% 1/8 w	
A2R25	0683-3915	R: fxd comp 390 ohm ±5% 1/4 w	
A2R26	0698-4123	R: fxd prec met flm 499 ohm ±1% 1/8 w	
A2R27	0683-2225	R: fxd comp 2200 ohm ±5% 1/4 w	
A2R28	0684-1001	R: fxd comp 10 ohm ±10% 1/4 w	
A2R29	0683-3915	R: fxd comp 390 ohm ±5% 1/4 w	
A2R30	0683-3945	R: fxd comp 390 K ±5% 1/4 w	
A2R31	2100-0092	R: var comp pot lin 10 K ±20% 0.15 w	
A2R32	0684-4721	R: fxd 4700 ohm ±10% 1/4 w	
A2R33	0757-0442	R: fxd prec met flm 10 K ±1% 1/8 w	
A2R34	0698-3260	R: fxd prec met flm 464 K ±1% 1/8 w	
A2R35	0757-0401	R: fxd prec met flm 100 ohm ±1% 1/8 w	
A2R36	0698-3179	R: fxd prec met flm 2550 ohm ±1% 1/8 w	
A2R37	0684-1011	R: fxd comp 100 ohm ±10% 1/4 w	
A2R38	2100-0277	R: var comp pot lin 500 ohm ±20% 0.15 w	
A2R39	0757-0346	R: fxd prec met flm 10.0 ohm ±1% 1/8 w	
A2R40	0698-3434	R: fxd prec met flm 34.8 ohm ±1% 1/8 w	
A2R41	0698-3147	R: fxd prec met flm 191 ohm ±1% 1/8 w	
A2R42	0698-4126	R: fxd prec met flm 35.7 ohm ±1% 1/8 w	
A2R43	0698-3262	R: fxd prec 40.2 ohm ±1% 1/8 w	
A2R44	0757-0284	R: fxd prec 150 ohm ±1% 1/8 w	
A2R45	0757-0381	R: fxd prec met flm 15.0 ohm ±1% 1/8 w	
A2R46	0757-0273	R: fxd prec met flm 3010 ohm ±1% 1/8 w	
A2R47	0698-3486	R: fxd prec met flm 232 ohm ±1% 1/8 w	
A2R48	0757-0407	R: fxd prec met flm 200 ohm ±1% 1/8 w	
A2R49	0757-0273	R: fxd prec met flm 3.010 ohm ±1% 1/8 w	
A2R50	0698-0085	R: fxd prec met flm 2610 ohm ±1% 1/8 w	
A2R51	0757-0284	R: fxd prec 150 ohm ±1% 1/8 w	
A2R52	0684-1011	R: fxd comp 100 ohm ±10% 1/4 w	

Table 7-1. Reference Designation Index (Cont'd)

REFERENCE DESIGNATION	-hp- PART NO.	DESCRIPTION	NOTE
A2R53	0757-0283	R: fxd prec met flm 2000 ohm ±1% 1/8 w	
A2R54	0698-3358	R: fxd prec met flm 1000 ohm ±1/2% 1/8 w	
A2R55	0683-2025	R: fxd comp 2000 ohm ±5% 1/4 w	
A2R56	0757-0458	R: fxd prec met flm 51.1 K ±1% 1/8 w	
A2R57	0757-0428	R: fxd prec met flm 1620 ohm ±1% 1/2 w	
A2R58	0683-1035	R: fxd comp 10 K ±5% 1/4 w	
A2R59	2100-0962	R: var comp pot lin 3000 ohm ±30% 1/4 w	
A2R60	0757-0459	R: fxd prec met flm 56.2 K ±1% 1/8 w	
A2R61	0683-3335	R: fxd comp 33 K ±5% 1/4 w	
A2R62	0757-0393	R: fxd prec met flm 47.5 ohm ±1% 1/8 w	
A2R63	0757-0401	R: fxd prec met flm 100 ohm ±1% 1/8 w	
A2R64	0757-0824	R: fxd prec met flm 2000 ohm ±1% 1/2 w	
A2R65	0698-4125	R: fxd prec met flm 953 ohm ±1% 1/8 w	
A2R66	0757-0400	R: fxd prec met flm 90.9 ohm ±1% 1/8 w	
A2R67	0683-3915	R: fxd comp 390 ohm ±5% 1/4 w	
A2R68	0683-4325	R: fxd comp 4.3 K ±5% 1/4 w	
A2R70	0757-0457	R: fxd prec met flm 47.5 K ±1% 1/8 w	
DS1	1450-0048	DS:Pilot Indicator NE-2H neon in red plastic body LINE	
J1	1250-0118	J: BNC input front	
J2		J: Rear terminal DC OUTPUT	
J3	1251-1009	J: Connector AC OUTPUT mates with 8120-0078, 8120-0231	
J4		J: Rear terminal BATTERY VOLTAGE input	
M1	1120-1103	M: Log (400 EL only)	
M1	1120-0902	M: Linear	
M1	1120-0908	M: Linear (Option 01 only)	
S1	3101-0036	S: tog SPST ON 3 amps 250 v ac-dc	
S2	3100-1718	S: Range blank	
S2	00400-61901	S: assembly RANGE includes: S2C1 thru S2C4 S2CR1 and S2CR2 S2R1 thru S2R14	
S2C1	0160-0205	C: fxd 10 pf ±5%	
S2C2	0160-0181	C: fxd mica 30 pfd ±5%	
S2C3	0160-2024	C: fxd mica 75 pf ±5% 500 vdcw	
S2C4	0180-0101	C: fxd Ta 1.8 µf ±10% 35 vdcw	
S2CR1 and S2CR2	1901-0040	CR: 30 ma at +1 v 30 piv 2 pf 2 ns	
S2R1	0757-0715	R: fxd prec met flm 150 ohm ±1% 1/4 w	
S2R2	0757-0069	R: fxd prec met flm 121 ohm ±1% 1/4 w	
S2R3	0757-0178	R: fxd prec met flm 100 ohm ±1% 1/4 w	
S2R4	0698-4119	R: fxd prec met flm 410.26 ohm ±.1% 1/4 w	
S2R5	0698-4118	R: fxd prec met flm 277.48 ohm ±.1% 1/4 w	
S2R6	0698-4119	R: fxd prec met flm 410.26 ohm ±.1% 1/4 w	
S2R7	0698-4118	R: fxd prec met flm 277.48 ohm ±.1% 1/4 w	
S2R8	0698-4119	R: fxd prec met flm 410.26 ohm ±.1% 1/4 w	
S2R9	0698-4118	R: fxd prec met flm 277.48 ohm ±.1% 1/4 w	
S2R10	0698-4119	R: fxd prec met flm 410.26 ohm ±.1% 1/4 w	

Table 7-1. Reference Designation Index (Cont'd)

REFERENCE DESIGNATION	-hp- PART NO.	DESCRIPTION	NOTE
S2R11	0698-4118	R: fxd prec met flm 277. 48 ohm ±. 1% 1/4 w	
S2R12	0698-4119	R: fxd prec met flm 410. 26 ohm ±. 1% 1/4 w	
S2R13	0698-4117	R: fxd prec met flm 189. 72 ohm ±. 1% 1/4 w	
S2R14	0684-1031	R: fxd comp 10 K ±10% 1/4 w	
S2	00400-61902	S: RANGE assembly (Option 02 only) includes: S2C1 thru S2C4 S2R1 thru S2R14	
S2C1	0160-0205	C: fxd mica 10 pf ±5%	
S2C2	0160-0181	C: fxd mica 18 - 30 pf ±5%	
S2C3	0160-2024	C: fxd mica 75 pf ±5% 500 vdcw	
S2C4	0180-0100	C: fxd Ta 4. 7 µf ±10% 35 vdcw	
S2R1	0757-0715	R: fxd prec met flm 150 ohm ±1% 1/4 w	
S2R2	0757-0178	R: fxd prec met flm 100 ohm ±1% 1/4 w	
S2R3	0698-4110	R: fxd prec met flm 49. 9 ohm ±1% 1/4 w	
S2R4	0698-4119	R: fxd prec met flm 410. 26 ohm ±. 1% 1/4 w	
S2R5	0698-4118	R: fxd prec met flm 277. 48 ohm ±. 1% 1/4 w	
S2R6	0698-4119	R: fxd prec met flm 410. 26 ohm ±. 1% 1/4 w	
S2R7	0698-4118	R: fxd prec met flm 277. 48 ohm ±. 1% 1/4 w	
S2R8	0698-4119	R: fxd prec met flm 410. 26 ohm ±. 1% 1/4 w	
S2R9	0698-4118	R: fxd prec met flm 277. 48 ohm ±. 1% 1/4 w	
S2R10	0698-4119	R: fxd prec met flm 410. 26 ohm ±. 1% 1/4 w	
S2R11	0698-4118	R: fxd prec met flm 277. 48 ohm ±. 1% 1/4 w	
S2R12	0698-4119	R: fxd prec met flm 410. 26 ohm ±. 1% 1/4 w	
S2R13	0698-4117	R: fxd prec met flm 189. 72 ohm ±. 1% 1/4 w	
S2R14	0684-1031	R: fxd comp 10 K ±10% 1/4 w	
S3	3101-0033	S: sl DPDT 115/230 v 0. 5 amp 125 vdc 3 amp 125 vac	
S3R1		R: var 200 K log db tấp	
T1	9100-1321	T: line	
		MECHANICAL PARTS	
MP1	0370-0112	Knob: bar w/ one arrow black	
MP2	0370-0113	Knob: bar (Option 02 only) 3/4 inch diam black	
MP3	0370-0114	Knob: round red (Option 02 only) 5/8 inch diam	
MP4	1205-0033	Heat dissipator: semiconductor	
MP5	0380-0037	Spacer Captive Al number 6 hardware	
MP6	1400-0084	Holder: fuse extractor post type black bakelite body	
MP7	00400-05501	Can: shield	
MP8	00400-04101	Cover: attenuator	
MP9	1490-0031	Stand: 1/3 module tilt	
MP10	00400-00202	Panel: rear	
MP11	00400-00201	Panel: front	
MP12	5020-0704	Meter: trim third module	
MP13	5020-0704	Meter: trim third module	
MP14	5060-0703	Frame: 6 x 11 sub module	
MP15	5060-0727	Foot assembly: 1/3 module	
MP16	1510-0008	Binding Post assembly: red w/o solder turret	
MP17	1510-0009	Binding Post assembly: black insulator	
MP18	5060-0709	Cover assembly: top 5 x 11 SM	

Table 7-1. Reference Designation Index (Cont'd)

REFERENCE DESIGNATION	-hp- PART NO.	DESCRIPTION	NOTE
		MECHANICAL PARTS (cont'd)	
MP19	5000-0703	Cover: side 6 x 11 SM	
MP20	5000-0711	Cover: bottom 5 x 11 SM	
MP21	00400-01201	Plate: grounding	
MP22	0340-0090	Insulator: BP double w/locating key p/o J2	
MP23	0340-0086	Insulator: BP double w/o locating key p/o J2	
MP24	0340-0091	Insulator: BP triple in line w/locating key p/o J4	
MP25	0340-0087	Insulator: BP triple in line p/o J4	
MP26	00400-00602	Shield, see Figure 7-1	
MP27	00400-00603	Shield, see Figure 7-1	
MP28	00400-00604	Shield, see Figure 7-1	
MP29	5020-0700	Spacer: cabinet third module	
MP30	5040-0700	Hinge: tilt stand third module	
		MISCELLANEOUS	
	00400-26501	Board: blank	
	8120-0078	Cord Set: power	
	0340-0060	Insulator: feed-thru teflon bushing w/clover leaf receptacle	
	0340-0109	Insulator: nylon threaded	
	00400-90000	Manual: operating and service of -hp- Model 400E/EL	

Table 7-2. Replaceable Parts

-hp-PART NO.	DESCRIPTION	MFR	MFR PART NO.	TQ	RS
0130-0016	C: var cer 5 - 25 pf	72982	557-019-C0P039R	1	
0132-0003	C: var trimmer 0.7 - 3 pf terminal spacing 0°	72982	535-016-4R	1	
0140-0145	C: fxd mica 22 pf ±5%	14655	RDM15C220J5C	1	
0140-0149	C: fxd mica 470 pf ±5%	14655	RDM15F471J3S	1	
0140-0190	C: fxd mica 39 pf ±5%	00853	RDM15E390J3C	1	
0140-0194	C: fxd mica 110 pf ±5%	00853	RDM15F111J3C	2	
0140-0198	C: fxd mica 200 pf ±5%	00853	RDM15F201J3C	2	
0140-0202	C: fxd mica 15 pf ±5%	00853	RDM15C150J5C	1	
0140-0203	C: fxd mica 30 pf ±5%	00853	RDM15E300J5C	1	
0150-0015	C: fxd TiO_2 2.2 pf ±10% 500 vdcw	82142	Type JM obd	1	
0150-0050	C: fxd cer disc 1000 pf GMV 600 vdcw	01281	Type E obd	1	
0150-0084	C: fxd cer 0.1 µf +80% -20% 50 vdcw	72982	845-222Y5V0104Z	1	
0150-0093	C: fxd cer durez coated disc 0.01µf +80% -20% 100 vdcw	91418	TA obd	7	
0150-0098	C: cer disc 0.01 µf ±20% 1000 vdcw	91418	B obd	1	
0150-0122	C: fxd cer 2000 pf ±20% 500 vdcw	72982	801-000-Y5S-202M	2	
0160-0181	C: fxd mica 30 pfd ±5%	00853	RDM15E300J3S	1	
0160-0205	C: fxd 10 pf ±5%	00853	RDM15C100J5S	1	
0160-2024	C: fxd mica 75 pf ±5% 500 vdcw	14655	RDM15E750J5S	1	
0180-0059	C: fxd elect 10 µf +100% -10% 25 vdcw	56289	30D106G025BB4	1	
0180-0061	C: fxd elect 100 µf +100% -10% 15 vdcw	56289	30D107G015DD4	1	
0180-0064	C: fxd elect 35 µf +100% -10% 6 vdcw	56289	30D346G006BB4	2	
0180-0100	C: fxd Ta 4.7 µf ±10% 35 vdcw	14433	SM4.7NF	4	
0180-0101	C: fxd Ta 1.8 µf ±10% 35 vdcw	14433	SM1.8NF	4	
0180-0137	C: fxd Ta elect 100 µf ±20% 10 vdcw	81856	K100J10S	2	
0180-0142	C: fxd Al elect 20 µf +100% -10% 25 vdcw	56289	Type 40D D36039	2	
0180-0149	C: fxd Al elect 65 µf +100% -10% 60 vdcw	56289	Type 30D D36978	2	
0180-0155	C: fxd Ta elect 2.2 µf ±20% 20 vdcw	56289	150D225X0020A2	2	
0180-0354	C: fxd Ta elect 40 µf ±5% 1- vdcw	56289	150D406X5010B2	2	
0180-1779	C: fxd Ta elect 18 µf 35 vdcw	56289	150D186X9035R2	2	
0180-1780	C: fxd Al elect 500 µf +75% -10% 10 vdcw	56289	39D507G010EJ4	1	
0180-1793	C: fxd 450 mfd +30% -10%	56289	30D Special	1	
0180-1794	C: fxd Ta elect 22 µf 35 vdcw	56289	150D226X9035R2	1	
0340-0060	Insulator: feed-thru teflon bushing w/ clover leaf receptacles	98291	FT-E-15 obd	11	
0340-0086	Insulator: BP Double w/o locating key p/o J2	28480	0340-0086	1	
0340-0087	Insulator: BP Triple in line p/o J4	28480	0340-0087	1	
0340-0090	Insulator: BP Double w/ locating key	28480	0340-0090	1	
0340-0091	Insulator: BP Triple in line w/ locating key	28480	0340-0091	1	
0340-0109	Insulator: Nylon threaded	02768	212-160402-00-0101	6	
0370-0112	Knob: bar w/ one arrow black	28480	0370-0112	1	
0370-0113	Knob: bar 3/4 inch diameter black (Option 02 only)	28480	0370-0113	1	
0370-0114	Knob: round 5/8 inch diameter red (Option 02 only)	28480	0370-0114	1	
0380-0037	Spacer: captive Al number 6 hardware	00866	obd	10	
0683-1005	R: fxd comp 10 ohm ±5% 1/4 w	01121	CB 1005	1	
0683-1035	R: fxd comp 10 K ±5% 1/4 w	01121	CB 1035	1	

Table 7-2. Replaceable Parts (Cont'd)

-hp-PART NO.	DESCRIPTION	MFR	MFR PART NO.	TQ	RS
0683-2025	R: fxd comp 2000 ohm ±5% 1/4 w	01121	CB 2025	5	
0683-2225	R: fxd comp 2200 ohm ±5% 1/4 w	01121	CB 2225	1	
0683-3335	R: fxd comp 33 K ±5% 1/4 w	01121	CB 3335	1	
0683-3915	R: fxd comp 390 ohm ±5% 1/4 w	01121	CB 3915	3	
0683-3945	R: fxd comp 390 K ±5% 1/4 w	01121	CB 3945	1	
0683-4325	R: fxd comp 4.3 K ±5% 1/4 w	01121	CB 4325	2	
0683-4735	R: fxd comp 47 K ±5% 1/4 w	01121	CB 4735	1	
0683-6825	R: fxd comp 6800 ohm ±5% 1/4 w	01121	CB 6825	1	
0683-8235	R: fxd comp 82 K ±5% 1/4 w	01121	CB 8235	1	
0684-1001	R: fxd comp 10 ohm ±10% 1/4 w	01121	CB 1001	2	
0684-1011	R: fxd comp 100 ohm ±10% 1/4 w	01121	CB 1011	2	
0684-1031	R: fxd comp 10 K ±10% 1/4 w	01121	CB 1031	1	
0684-4721	R: fxd comp 4700 ohm ±10% 1/4 w	01121	CB 4721	1	
0686-2265	R: fxd comp 22 meg ±5% 1/2 w	01121	CB 2265	1	
0698-0085	R: fxd prec met flm 2610 ohm ±1% 1/8 w	75042	CEA T-O obd	1	
0698-3147	R: fxd prec met flm 191 ohm ±1% 1/8 w	75042	CEA T-O obd	1	
0698-3155	R: fxd prec met flm 4640 ohm ±1% 1/8 w	75042	CEA T-O obd	1	
0698-3156	R: fxd prec met flm 14.7 K ±1% 1/8 w	75042	CEA T-O obd	1	
0698-3179	R: fxd prec met flm 2550 ohm ±1% 1/8 w	75042	CEA T-O obd	1	
0698-3260	R: fxd prec met flm 464 K ±1% 1/8 w	75042	CEA T-O obd	1	
0698-3262	R: fxd prec 40.2 ohm ±1% 1/8 w	75042	CEA T-O obd	1	
0698-3358	R: fxd prec met flm 1000 ohm ±1/2% 1/8 w	75042	CEA T-O obd	1	
0698-3434	R: fxd prec met flm 34.8 ohm ±1% 1/8 w	75042	CEA T-O obd	1	
0698-3486	R: fxd prec met flm 232 ohm ±1% 1/8 w	75042	CEA T-O obd	1	
0698-4117	R: fxd prec met flm 189.72 ohm ±.1% 1/4 w	75042	CEA T-O obd	1	
0698-4118	R: fxd prec met flm 277.48 ohm ±.1% 1/4 w	75042	CEA T-O obd	4	
0698-4119	R: fxd prec met flm 410.26 ohm ±.1% 1/4 w	19701	MF6C T-3 obd	5	
0698-4121	R: fxd prec met flm 11.3 K ±1% 1/8 w	19701	MF5C T-O obd	1	
0698-4123	R: fxd prec met flm 499 ohm ±1% 1/8 w	19701	MFFC T-O obd	1	
0698-4125	R: fxd prec met flm 953 ohm ±1% 1/8 w	19701	MF5C T-O obd	1	
0698-4126	R: fxd prec met flm 35.7 ohm ±1% 1/8 w	19701	MF7C T-O obd	1	
0698-4128	R: fxd prec met flm 10.0 meg ±1/4% 1/2 w	03888	PME 70 obd	1	
0698-4129	R: fxd prec met flm 31.723 K ±0.1% 1/2 w	19701	MF5C T-3 obd	1	
0757-0069	R: fxd prec met flm 121 ohm ±1% 1/4 w	75042	CEB T-O obd	1	
0757-0178	R: fxd prec met flm 100 ohm ±1% 1/4 w	75042	CEB T-O obd	2	
0757-0283	R: fxd prec met flm 2000 ohm ±1% 1/8 w	19701	MF5C T-O obd	1	
0757-0284	R: fxd prec 150 ohm ±1% 1/8 w	75042	CEA T-O obd	2	
0757-0289	R: fxd prec met flm 1330 ohm ±1% 1/8 w	19701	MF5C T-O obd	1	
0757-0273	R: fxd prec met flm 3010 ohm ±1% 1/8 w	19701	MF5C T-O obd	2	
0757-0346	R: fxd prec met flm 10.0 ohm ±1% 1/8 w	19701	MF5C T-O obd	1	
0757-0381	R: fxd prec met flm 15.0 ohm ±1% 1/8 w	75042	CEA T-O obd	1	
0757-0391	R: fxd prec met flm 39.2 ohm ±1% 1/8 w	75042	CEA T-O obd	1	
0757-0393	R: fxd prec met flm 47.5 ohm ±1% 1/8 w	75042	CEA T-O obd	1	
0757-0400	R: fxd prec met flm 90.9 ohm ±1% 1/8 w	75042	CEA T-O obd	1	
0757-0401	R: fxd prec met flm 100 ohm ±1% 1/8 w	75042	CEA T-O obd	2	
0757-0407	R: fxd prec met flm 200 ohm ±1% 1/8 w	75042	CEA T-O obd	1	
0757-0416	R: fxd prec met flm 511 ohm ±1% 1/8 w	75042	CEA T-O obd	1	
0757-0428	R: fxd prec met flm 1620 ohm ±1% 1/2 w	75042	CEA T-O obd	1	
0757-0434	R: fxd prec met flm 3650 K ±1% 1/8 w	75042	CEA T-O obd	2	
0757-0442	R: fxd prec met flm 10 K ±1% 1/8 w	75042	CEA T-O obd	1	

Table 7-2. Replaceable Parts (Cont'd)

-hp-PART NO.	DESCRIPTION	MFR	MFR PART NO.	TQ	RS
0757-0447	R: fxd prec met flm 16.2 K ±1% 1/8 w	75042	CEA T-O obd	1	
0757-0457	R: fxd prec met flm 47.5 K ±1% 1/8 w	75042	CEA T-O obd	1	
0757-0458	R: fxd prec met flm 51.1 K ±1% 1/8 w	75042	CEA T-O obd	1	
0757-0459	R: fxd prec met flm 56.2 K ±1% 1/8 w	75042	CEA T-O obd	2	
0757-0715	R: fxd prec met flm 150 ohm ±1% 1/4 w	75042	CEA T-O obd	1	
0757-0794	R: fxd prec met flm 68.1 ohm ±1% 1/2 w	75042	CEA T-O obd	2	
0757-0808	R: fxd prec met flm 301 ohm ±1% 1/2 w	75042	CEC T-O obd	1	
0757-0824	R: fxd prec met flm 2000 ohm ±1% 1/2 w	75042	CEC T-O obd	2	
1120-0902	Meter: linear	28480	1120-0902	1	
1120-0908	Meter: linear (Option 02 only)	28480	1120-0908	1	
1120-1103	Meter: log (400 EL only)	28480	1120-1103	1	
1205-0033	Heat Dissipator: semiconductor	05820	NF-207 obd	1	
1250-0118	J: BNC input front	95712	30384-1	2	
1251-1009	Connector: AC OUTPUT mates with 8120-0078, 8120-0231 rear	82389	AC-3 obd	1	
1400-0084	Holder: fuse extractor post type bakelite body black	75915	342014	1	
1450-0048	DS: pilot indicator NE-2H neon red LINE	72664	599-124	1	
1490-0031	Stand: 1/3 module tilt	91260	obd	1	
1510-0008	Binding Post assembly: red w/o solder turret	28480	1510-0008	3	
1510-0009	Binding Post assembly: black insulator	28480	1510-0009	2	
1850-0064	Q: Ge PNP 2N183	86684	2N1183	1	
1850-0158	Q: Ge PNP 2N2635	04713	2N2635	1	
1853-0009	Q: Si PNP **	82647	SN5727	2	
1853-0010	Q: Si PNP **	04713	SM4713	1	
1853-0016	Q: Si PNP 2N3638	07263	2N3638	1	
1854-0033	Q: Si NPN 2N3391	24446	2N3391	2	
1854-0039	Q: Si NPN 2N3053	04713	2N3053	1	
1854-0042	Q: Si NPN **	04713	SM1570	1	
1854-0057	Q: Si NPN **	24446	16L64	3	
1854-0073	Q: Si NPN 2N3478	86684	2N3478	2	
1855-0016	Q: FET P Channel	28480	1855-0016	1	
1901-0025	CR: Si 100 ma +1 v 100 piv 12 pf	93332	D3072	2	
1901-0033	CR: Si 100 ma +1 v 180 wiv 13 pf	93332	D6238	6	
1901-0040	CR: 30 ma at +1 v 30 piv 2 pf 2 ns	03877	SC 5050	2	
1901-0044	CR: Si 20 ma +1 v 10 na -10 v 50 wiv 2 pf 6 ns	07910	SF42 obd	2	
1901-0456	CR: Si 35 ma 20 BV 1.2 pf	28480	1901-0456	2	
1901-3090	CR:			2	
1902-0031	CR: breakdown 12.7 v ±5% 400 mw	06486	obd	1	
1902-0182	CR: breakdown 20.5 v ±5% 400 mw	06486	obd	1	
1902-3125	CR: Si breakdown 6.98 v ±2% 400 mw	06486	obd	1	
1902-3179	CR: Si breakdown 11.8 v ±5% 400 mw	06486	obd	1	
1902-3222	CR: Si breakdown 17.4 v ±5% 500 mw	06486	SZ 10939-251	1	
2100-0092	R: var comp pot lin 10 K ±20% 0.15 w	71450	UPE 70RE obd	1	
2100-0093	R: var comp pot lin 20 K ±20% 0.10w	71450	UPE 70RE obd	1	
2100-0277	R: var comp pot lin 500 ohm ±20% 0.15 w	71450	UPE 70RE obd	1	
2100-0962	R: var comp pot lin 3000 ohm ±30% 1/4 w	90201	MTC-1 obd	1	
3100-1718	S: blank	28480	3100-1718	1	

Table 7-2. Replaceable Parts (Cont'd)

-hp-PART NO.	DESCRIPTION	MFR	MFR PART NO.	TQ	RS
3101-0033	S: sl DPDT 115/230 v 0. 5 amp 125 vdc 3 amp 125 vac	79727	G-326:6510	1	
3101-0036	S: tog SPST ON 3 amps 250 v ac-dc	88140	8928K61	1	
5000-0703	Cover: side 6 x 11 SM	28480	5000-0703	2	
5000-0711	Cover assembly: bottom 5 x 11 SM	28480	5000-0711	1	
5020-0704	Meter: trim third module	28480	5020-0704	3	
5060-0709	Cover assembly: top 5 x 11 SM	28480	5060-0709	1	
5060-0727	Foot assembly: 1/3 mod.	28480	5060-0727	2	
8120-0078	Cord Set: power	28480	8120-0078	1	
9100-1321	Transformer	28480	9100-1321	1	
00400-00201	Panel: front	28480	00400-00201	1	
00400-00202	Panel: rear	28480	00400-00202	1	
00400-00602	Shield:	28480	00400-00602	1	
00400-00603	Shield:	28480	00400-00603	1	
00400-00604	Shield:	28480	00400-00604	1	
00400-01201	Plate: grounding	28480	00400-01201	1	
00400-04101	Cover: attenuator	28480	00400-04101	1	
00400-04401	Can: shield	28480	00400-05501	1	
00400-10499	Relay: reed Form B	28480	00400-10499	1	
00400-10500	Relay: reed Form A	28480	00400-10500	2	
00400-26501	Board: blank	28480	00400-26501	1	
00400-61901	S: range assembly	28480	00400-61901	1	
00400-66501	Board assembly: A2 board	28480	00400-66501	1	
00400-66502	Board assembly: etched circuit input attenuator A1	28480	00400-66502	1	
00400-90000	Manual: Operating and Service of -hp- 400E/EL	28480	00400-90000	1	

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks.

Code No.	Manufacturer	Address
00000	U.S.A. Common	Any supplier of U.S.
00136	McCoy Electronics	Mount Holly Springs, Pa.
00213	Sage Electronics Corp.	Rochester, N. Y.
00334	Humidaire Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00373	Garlock Packing Co., Electronic Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.
00853	Sangamo Electric Company, Ordill Division (Capacitors)	Marion, Ill.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	TRW Semiconductors Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc. Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Ind.
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01930	Amerock Corp	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America, Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co.	Morristown, N.J.
03954	Air Marine Motors, Inc.	Los Angeles, Calif.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04013	Taurus Corp.	Lambertville, N. J.
04062	Elmenco Products Co.	New York, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04298	Elgin National Watch Co., Electronics Division	Burbank, Calif.
04354	Precision Paper Tube Co.	Chicago, Ill.
04404	Oymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Prods., Inc. Electronic Tube Div.	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc., Western Div.	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04777	Automatic Electric Sales Corp.	Northlake, Ill.
04796	Sequoia Wire & Cable Co.	Redwood City, Calif.
04811	Precision Coil Spring Co.	El Monte, Calif.
04870	P. M. Motor Company	Chicago 44, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Calif.
05593	Illumitronic Engineering Co.	Sunnyvale, Calif.
05616	Cosmo Plastic (c/o Electrical Spec. Co.)	Cleveland, Ohio
05624	Barber Colman Co.	Rockford, Ill.
05728	Tiffen Optical Co.	Roslyn Heights, Long Island, N.Y.
05729	Metropolitan Telecommunications Corp., Metro Cap. Division	Brooklyn, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
05820	Wakefield Engineering Inc.	Wakefield, Mass.
06004	The Bassick Co.	Bridgeport, Conn.
06175	Bausch and Lomb Optical Co.	Rochester, N.Y.
06402	E.T.A. Products Co. of America	Chicago, Ill.
06475	Western Devices, Inc.	Inglewood, Calif.
06540	Amatom Electronic Hardware Co. Inc.	New Rochelle, N. Y.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06751	U. S. Semcor Division of Nuclear Corp. of America	Phoenix, Arizona
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07088	Kelvin Electric Co.	Van Nuys, Calif.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07149	Filmohm Corp.	New York, N. Y.
07233	Cinch-Graphik Co.	City of Industry, Calif.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07322	Minnesota Rubber Co.	Minneapolis, Minn.
07387	The Bittcher Corp.	Los Angeles, Calif.
07700	Technical Wire Products	Springfield, N.J.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07966	Shockley Semi-Conductor Laboratories	Palo Alto, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08289	Blinn, Delbert, Co.	Pomona, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada.
08717	Sloan Company	Burbank, Calif.
08718	Cannon Electric Co., Phoenix Div.	Phoenix, Ariz.
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S., Inc.	Lowell, Mass.
08984	Mel-Rain	Indianapolis, Ind.
09026	Babcock Relays, Inc.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09145	Atohm Electronics	Sun Valley, Calif.
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
09664	The Bristol Co.	Waterbury, Conn.
10214	General Transistor Western Corp.	Los Angeles, Calif.
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11312	Microwave Electronics Corp.	Palo Alto, Calif.
11534	Duncan Electronic, Inc.	Santa Ana, Calif.
11711	General Instrument Corporation Semiconductor Division	Newark, N.J.
11717	Imperial Electronic, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12136	Philadelphia Handle Co.	Camden, N. J.
12697	Clarostat Mfg. Co.	Dover, N.H.
12859	Nippon Electric Co., Ltd.	Tokyo, Japan
12930	Delta Semiconductor Inc.	Newport Beach, Calif.
13103	Thermalloy	Dallas, Texas
13396	Telefunken (G.M.B.H.)	Hannover, Germany
13835	Midland Mfg. Co.	Kansas City, Kansas
14099	Sem-Tech	Newbury Park, Calif.
14193	Calif. Resistor Corp.	Santa Monica, Calif.
14298	American Components, Inc.	Conshohocken, Pa.
14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.
14960	Williams Mfg. Co.	San Jose, Calif.
15203	Webster Electronics Co. Inc.	Brooklyn, N.Y.
15291	Adjustable Bushing Co.	N. Hollywood, Calif.
15772	Twentieth Century Coil Spring Co.	Santa Clara, Calif.
15909	The Daven Co.	Livingston, N.J.
16037	Spruce Pine Mica Co.	Spruce Pine, N. C.
16352	Computer Diode Corp.	Lodi, N. J.
16688	De Jur-Amsco Corporation	Long Island City 1, N.Y.
16758	Delco Radio Div. of G.M. Corp.	Kokomo, Ind.
17109	Thermonetics Inc.	Canoga Park, Calif.
17474	Tranex Company	Mountain View, Calif.
18486	Radio Industries	Des Plaines, Ill.
18583	Curtis Instrument Inc.	Mt. Kisco, N.Y.
18873	E.I. DuPont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19701	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21226	Executive, Inc.	New York, N.Y.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
21964	Fed. Telephone and Radio Corp.	Clifton, N.J.
24446	General Electric Co.	Schenectady, N.Y.
24455	G.E., Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26365	Gries Reproducer Corp.	New Rochelle, N.Y.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
36196	Stanwyck Corp.	Hawkesbury, Ontario, Canada
37942	P.R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C.A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
49956	Raytheon Company	Lexington, Mass.
52090	Rowan Controller Co.	Baltimore, Md.
63743	Ward Leonard Electric	Mt. Vernon, N.Y.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
59730	Thomas & Betts Co.	Elizabeth 1, N.J.
60741	Tripplett Electrical Inc.	Bluffton, Ohio
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Swissvale, Pa.
62119	Universal Electric Co.	Owosso, Mich.
63743	Ward-Leonard Electric Co.	Mt. Vernon, N.Y.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
66295	Wittek Manufacturing Co.	Chicago 23, Ill.
66346	Wollensak Optical Co.	Rochester, N.Y.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70319	Allmetal Screw Prod. Co., Inc.	Garden City, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	New York, N.Y.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio Inc.	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Electronic Prod. Corp.	Plainville, Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
71436	Chicago Condenser Corp.	Chicago, Ill.
71450	CTS Corp.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C.P. Clare & Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71616	Commercial Plastics Co.	Chicago, Ill.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A.O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72092	Eitel-McCullough, Inc.	San Bruno, Calif.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
71707	Coto Coil Co., Inc.	Providence, R.I.
72354	John E. Fast & Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72699	General Instrument Corp., Semiconductor Div.	Newark, N.J.
72758	Girard-Hopkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72964	Robert M. Hadley Co.	Los Angeles, Calif.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73076	H.M. Harper Co.	Chicago, Ill.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co, Inc.	Hicksville, N.Y.
73490	Beckman Helipot Corp.	So. Pasadena, Calif.
73506	Bradley Semiconductor Corp.	Hamden, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
73734	Federal Screw Prod. Co.	Chicago, Ill.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73846	Goshen Stamping & Tool Co.	Goshen, Ind.
73899	JFD Electronics Corp.	Brooklyn, N. Y.
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74276	Signalite Inc.	Neptune, N.J.
74455	J.H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	Jones, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littlefuse Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C.W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J.W. Miller Co.	Los Angeles, Calif.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio.
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	Bendix Pacific Division of Bendix Corp.	No. Hollywood, Calif.
77075	Pacific Metals Co.	San Francisco, Calif.
77221	Phaostran Instrument and Electronic Co.	South Pasadena, Calif.
77250	Phoell Mfg. Co.	Chicago, Ill.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	Potter and Brumfield, Div. of American Machine and Foundry	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
77969	Rubbercraft Corp. of Calif.	Torrance, Calif.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78283	Signal Indicator Corp.	New York, N.Y.
78290	Struthers-Dunn Inc.	Pitman, N.J.
78452	Thompson-Bremer & Co.	Chicago, Ill.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78493	Standard Thomson Corp.	Waltham, Mass.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	Pasadena, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80120	Schnitzer Alloy Products	Elizabeth, N.J.
80130	Times Facsimile Corp.	New York, N.Y.
80131	Electronic Industries Association	Any brand tube meeting EIA standards Washington, D.C.
80207	Unimax Switch, Div. of W.L. Maxson Corp.	Wallingford, Conn.
80223	United Transformer Corp.	New York, N.Y.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Laboratories, Inc.	Riverside, Calif.
80411	Acro Div. of Robertshaw Fulton Controls Co.	Columbus 16, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80509	Avery Adhesive Label Corp.	Monrovia, Calif.
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81073	Grayhill Co.	LaGrange, Ill.
81095	Triad Transformer Corp.	Venice, Calif.
81312	Winchester Electronics Co., Inc.	Norwalk, Conn.

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APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

Code No.	Manufacturer	Address
81349	Military Specification	.....
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Components Div., Industr. Tube Operations	Newton, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81541	The Airpax Products Co.	Cambridge, Mass.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Ill.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Allen B. DuMont Labs, Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc. Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls, Inc., Div. of Texas Instruments, Inc., Spencer Prods.	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Manufacturing Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83053	Western Washer Mfr. Co.	Los Angeles, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	Pyramid Electric Co.	Darlington, S.C.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Springfield, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83315	Hubbell Corp.	Mundelein, Ill.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83740	Eveready Battery	New York, N.Y.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronis, Inc.	New York, N.Y.
84396	A. J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85471	A. B. Boyd Co.	San Francisco, Calif.
85474	R.M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86197	Clifton Precision Products	Clifton Heights, Pa.
86579	Precision Rubber Products Corp.	Dayton, Ohio
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
87216	Philco Corporation (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
87664	Van Waters & Rogers Inc.	Seattle, Wash.
87930	Tower Mfg. Corp	Providence, R. I.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
88698	General Mills, Inc.	Buffalo, N.Y.
89231	Graybar Electric Co.	Oakland, Calif.
89462	Waldes Kohinoor, Inc.	Cambridge, Mass.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
89636	Carter Parts Div. of Economy Baler Co.	Chicago, Ill.
89665	United Transformer Co.	Chicago, Ill.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91345	Miller Dial & Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Brothers', Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91929	Minneapolis-Honeywell Regulator Co., Microswitch Div.	Freeport, Ill.
91961	Nahm-Bros. Spring Co.	Oakland, Calif.
92180	Tru-Connector Corp.	Peabody, Mass.
92196	Universal Metal Prod., Inc.	Bassett Puente, Calif.
92367	Elgeet Optical Co., Inc.	Rochester, N.Y.
92607	Tinsolite Insulated Wire Co.	Tarrytown, N.Y.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93788	Howard J. Smith Inc.	Port Monmouth, N. J.
93929	G. V. Controls	Livingston, N. J.
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94137	General Cable Corp.	Bayonne, N.J.
94144	Raytheon Mfg. Co., Industrial Components Div., Receiving Tube Operation	Quincy, Mass.
94145	Raytheon Mfg. Co., Semiconductor Div., California Street Plant	Newton, Mass.
94148	Scientific Radio Products, Inc.	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	East Paterson, N.J.
94222	Southco Div. of S. Chester Corp.	Lester, Pa.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
94330	Wire Cloth Products Inc.	Chicago, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
95023	Philbrick Researchers, Inc.	Boston, Mass.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95264	Lerco Electronics, Inc.	Burbank, Calif.
95265	Natioaal Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95348	Gordas Corp.	Bloomfield, N.J.
95354	Methode Mfg. Co.	Chicago, Ill.
95712	Dage Electric Co., Inc.	Franklin, Ind.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Division of Aerovox	Olean, N.Y.
96256	Thordarson-Meissner Div. of Maguire Industries, Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
97979	Reon Resistor Corp.	Yonkers, N.Y.
98141	Axel Brothers Inc.	Jamaica, N.Y.
98159	Rubber Teck, Inc.	Gardena, Calif.
98220	Francis L. Mosley	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98405	Carad Corp.	Redwood City, Calif.
98731	General Mills	Minneapolis, Minn.
98821	North Hills Electric Co.	Mineola, N.Y.
98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99515	Marshall Industries, Electron Products Division	Pasadena, Calif.
99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Semiconductor Div. of Hoffman Electronics Corp.	Evanston, Ill.
99957	Technology Instrument Corp of Calif.	Newbury Park, Calif.

THE FOLLOWING H-P VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

J0000	Winchester Electronics, Inc.	Santa Monica, Calif.
0000F	Malco Tool and Die	Los Angeles, Calif.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AA	British Radio Electronics Ltd.	Washington, D.C.
000AB	ETA	England
000AC	Indiana General Corp., Elect. Div.	Indiana
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000MM	Rubber Eng. & Development	Hayward, Calif.
000NN	A "N" D Manufacturing Co.	San Jose 27, Calif.
000QQ	Cooltron	Oakland, Calif.
000SS	Control of Elgin Watch Co.	Burbank, Calif.
000WW	California Eastern Lab.	Burlingame, Calif.
000YY	S.K. Smith Co.	Los Angeles 45, Calif.

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HP SALES AND SERVICE OFFICES IN THE U.S. AND CANADA

ALABAMA

Huntsville, 35801
Hewlett-Packard
Southern Sales Division
Holiday Office Ctr., Suite 18
(205) 881-4591
TWX: 510-579-2204

ARIZONA

Scottsdale, 85251
Hewlett-Packard
Neely Sales Division
3009 No. Scottsdale Rd.
(602) 945-7601
TWX: 602-949-0111

Tucson, 85716
Hewlett-Packard
Neely Sales Division
232 So. Tucson Blvd.
(602) 623-2564
TWX: 602-792-2759

CALIFORNIA

Los Angeles Area
Hewlett-Packard
Neely Sales Division
3939 Lankershim Blvd.
North Hollywood 91604
(213) 877-1282 and 766-3811
TWX: 910-499-2170

Sacramento, 95821
Hewlett-Packard
Neely Sales Division
2591 Carlsbad Ave.
(916) 482-1463
TWX: 916-444-8683

San Diego, 92106
Hewlett-Packard
Neely Sales Division
1055 Shafter Street
(714) 223-8103
TWX-714-276-4263

San Francisco Area
Hewlett-Packard
Neely Sales Division
1101 Embarcadero Rd.
Palo Alto 94303
(415) 327-6500
TWX: 910-373-1280

COLORADO

Englewood, 80110
Hewlett-Packard
Neely Sales Division
7965 East Prentice
(303) 771-3455
TWX: 303-771-3056

CONNECTICUT

Middletown, 06458
Hewlett-Packard
Yewell Sales Division
589 Saybrook Rd.
(203) 346-6611
TWX: 710-428-2036

FLORIDA

Miami, 33125
Hewlett-Packard
Florida Sales Division
2907 Northwest 7th St.
(305) 635-6461

Orlando, 32803
Hewlett-Packard
Florida Sales Division
621 Commonwealth Ave.
(305) 425-5541
TWX: 305-275-1234

St. Petersburg, 33708
Hewlett-Packard
Florida Sales Division
410-150th Ave., Madeira Beach
(813) 391-0211
TWX: 813-391-0666

GEORGIA

Atlanta, 30305
Hewlett-Packard
Southern Sales Division
3110 Maple Drive, N. E.
(404) 233-1141
TWX: 810-751-3283

ILLINOIS

Chicago, 60645
Hewlett-Packard
Crossley Sales Division
2501 West Peterson Ave.
(312) 275-1600
TWX: 910-221-0277

INDIANA

Indianapolis, 46205
Hewlett-Packard
Crossley Sales Division
3919 Meadows Dr.
(317) 546-4891
TWX: 317-635-4300

KENTUCKY

Louisville, 40218
Hewlett-Packard
Southern Sales Division
Suite 4, 3411 Bardstown Rd.
(502) 459-4140
TWX: 810-535-3128

MARYLAND

Baltimore, 21207
Hewlett-Packard
Horman Sales Division
6660 Security Blvd.
(301) 944-5400

Washington, D. C. Area
Hewlett-Packard
Horman Sales Division
941 Rollins Avenue
Rockville 20852
(301) 427-7560
TWX: 710-828-9684

MASSACHUSETTS

Boston Area
Hewlett-Packard
Yewell Sales Division
Middlesex Turnpike
Burlington 01804
(617) 272-9000
TWX: 710-332-0382

MICHIGAN

Detroit, 48235
Hewlett-Packard
Crossley Sales Division
14425 West Eight Mile Road
(313) 342-5700
TWX: 313-342-0702

MINNESOTA

St. Paul, 55114
Hewlett-Packard
Crossley Sales Division
842 Raymond Avenue
(612) 646-7881
TWX: 910-563-3734

MISSOURI

Kansas City, 64131
Harris-Hanson Company
7916 Paseo Street
(816) 444-9494
TWX: 816-556-2423

St. Louis, 63144
Harris-Hanson Company
2814 South Brentwood Blvd.
(314) 647-4350
TWX: 314-962-3933

NEW JERSEY

Asbury Park Area
Hewlett-Packard
Robinson Sales Division
Shrewsbury
(201) 747-1060

Englewood, 07631
Hewlett-Packard
RMC Sales Division
391 Grand Avenue
(201) 567-3933

NEW MEXICO

Albuquerque, 87108
Hewlett-Packard
Neely Sales Division
6501 Lomas Blvd., N. E.
(505) 255-5586
TWX: 910-989-1665

Las Cruces, 88001
Hewlett-Packard
Neely Sales Division
114 S. Water Street
(505) 526-2486
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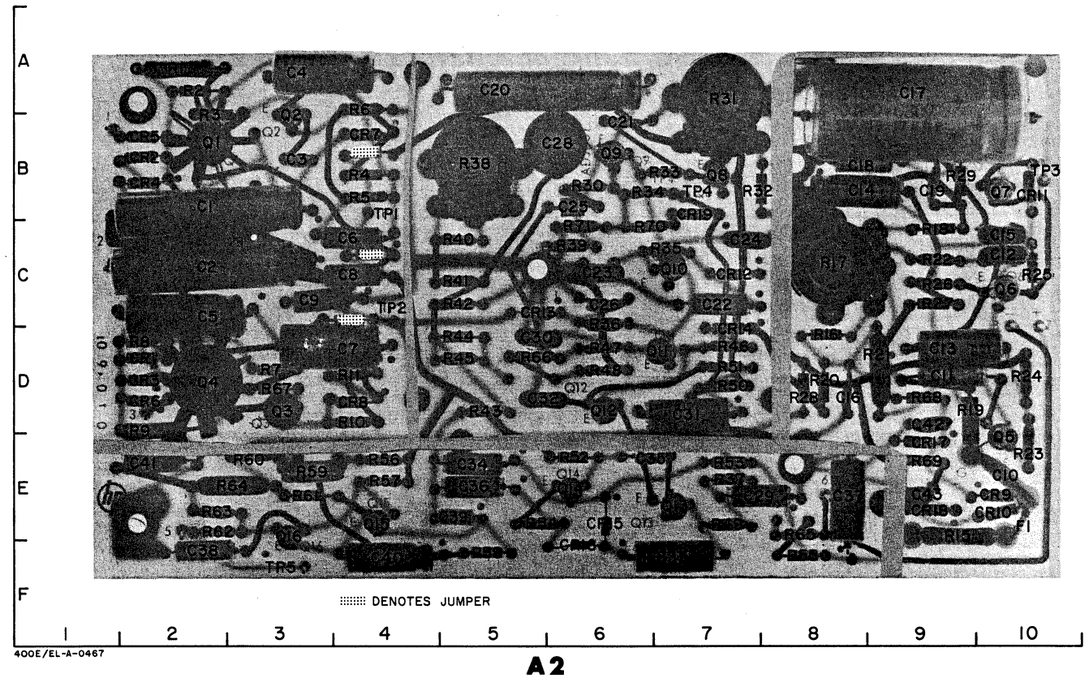
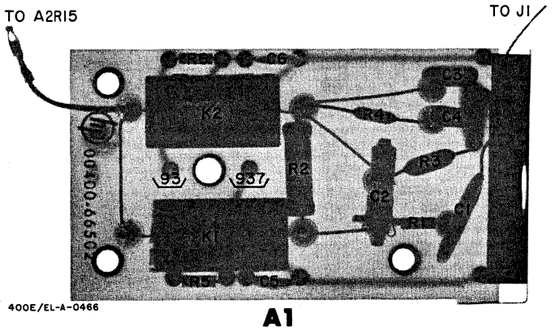


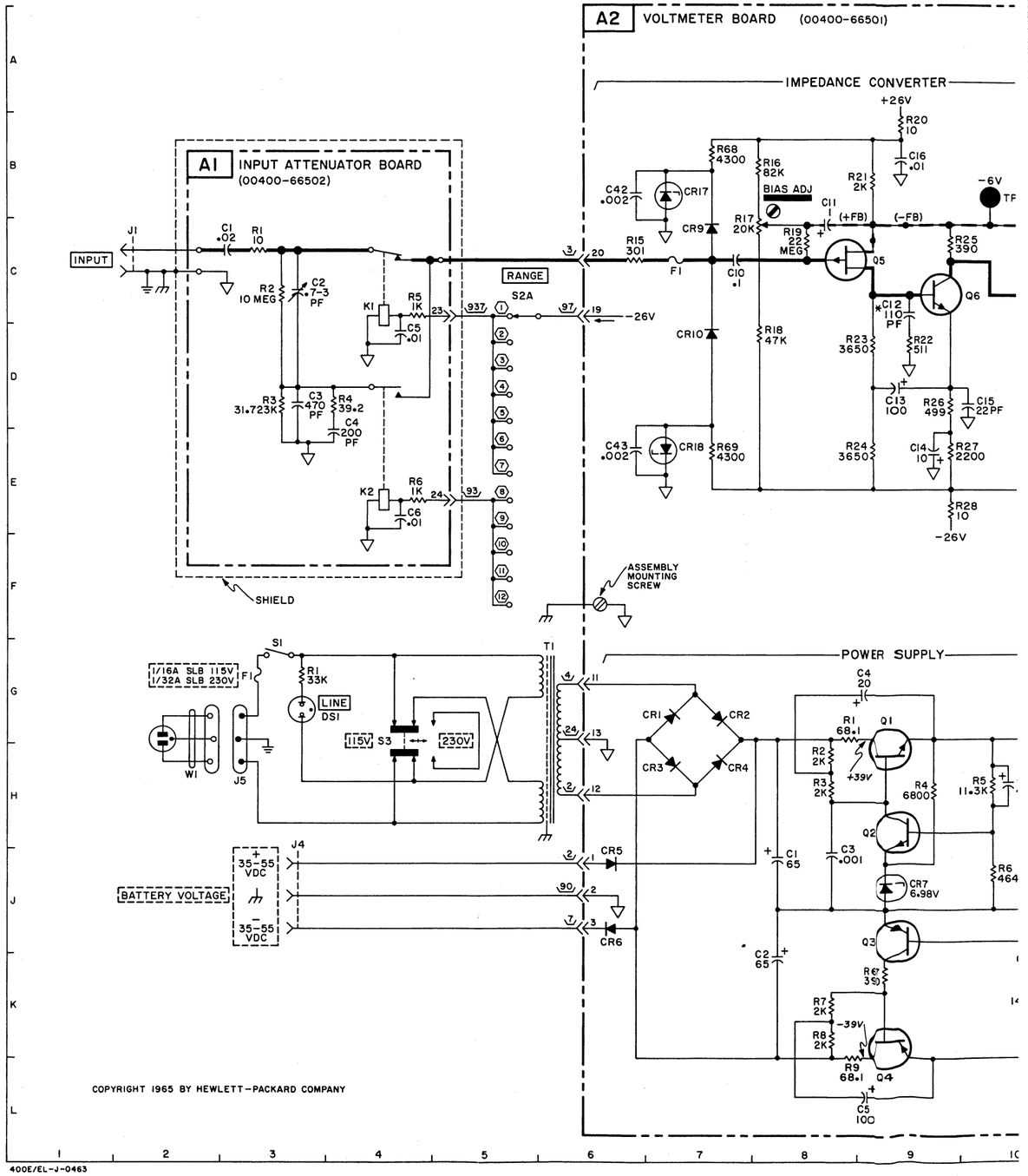
A2
(hp Part No. 00400-66501)



A1
(hp Part No. 00400-66502)

A2 ASSEMBLY COMPONENT LOCATIONS

	C	CR	Q	R	TP	F		C	R		R
1	B2	D2	B2	A2	B4	E10	25	B6	C10	49	E7
2	C2	B2	A3	A2	C4		26	C6	C9	50	D7
3	B3	D2	D3	A2	B10		27	--	C9	51	D7
4	A3	B2	D2	B4	B7		28	B6	D8	52	E6
5	C2	B2	E10	B4	F3		29	E8	B9	53	E7
6	C4	D2	C10	A4			30	D5	B6	54	E5
7	D4	B4	B10	D3			31	D7	A7	55	F8
8	C4	D4	B7	D2			32	D5	B8	56	E4
9	C3	E10	B6	D2			33	F7	B7	57	E4
10	E10	E10	C7	D4			34	E5	B7	58	F5
11	D9	B10	D7	D4			35	E7	C7	59	E3
12	C10	C7	D6	--			36	E5	C6	60	E3
13	D9	C5	E7	--			37	E8	E7	61	E3
14	B9	D7	E6	--			38	F2	B5	62	E2
15	C10	E6	E4	E9			39	E5	C6	63	E2
16	D8	F6	E3	D8			40	F4	C5	64	E3
17	A9	E9		C8			41	E2	C5	65	E8
18	B9	E9		C9			42	D9	C5	66	D5
19	B9	B7		D10			43	E9	D5	67	D3
20	A5			D8			44		D5	68	D9
21	B6			D9			45		D5	69	E9
22	C7			C9			46		D7	70	C7
23	C6			E10			47		D6	71	C6
24	C7			D10			48		D6	72	



A2 VOLTMETER BOARD (00400-66501)

IMPEDANCE CONVERTER

POST ATTENUATOR

METER AMPLIFIER

METER BRIDGE

AC OUTPUT CIRCUIT

POWER SUPPLY

TOR BOARD

RANGE

S2A

S2B & S2D

NOTE 7

S2CR1

S2CR2

ASSEMBLY MOUNTING SCREW

BIAS ADJ

10MC ADJ

400 CPS ADJ

OV ADJ

115V S3 230V

T1

+26V

-26V

-6V

+9V

0V

+1.3V

+.57V

-.45V

+6.7V

+7.5V

-6.98V

+39V

-39V

TP1

TP2

TP3

TP4

TP5

F1

K1

K2

R5 1K

R6 1K

C5 .01

C6 .01

C4 9.2 C4 100 PF

R15 301

R68 4300

R16 82K

R17 20K

R19 22 MEG

R21 2K

R20 10

C16 .01

C42 .002

CR17

CR9

C11 (+FB)

(-FB)

C10 .1

R18 47K

CR10

C43 .002

CR18

R69 4300

R23 3650

R22 511

C12 110 PF

C13 100

R26 499

C15 22PF

R24 3650

C14 10

R27 2200

R28 10

R25 390

CR11

C17 500

R29 390

C18 1.8

C19 .01

S2C1 10PF

S2R1 150

S2C2 30PF

S2R 100

S2R 121

S2R4 410.26

S2R5 277.48

S2R6 410.26

S2R7 277.48

S2R8 410.26

S2R9 277.48

S2R10 410.26

S2R11 277.48

S2R12 410.26

S2R13 189.72

R31 10K

R32 4700

CR19 12.7V

R70 47.5K

R71 56.2K

Q8

Q9

Q10

Q11

Q12

Q13

R33 10K

C21 .01

C22 4.7

R35 100

R34 464K

R30 196K

C25 2.2PF

C24 24PF

C23 200 PF

R36 2550

C26 .01

CR13 20.5V

CR12 17.4V

CR14 11.8V

R46 3010

R47 301

R48 200

R66 90.9

C30 15PF

R50 2610

R51 150

C31* 22

C32 39PF

C20 450

R37 100

C29 4.7

R49 3010

C28 8-50PF

R38 100

R40 34.8

R41 191

R39 10

R42 35.7

R43 40.2

R44* 150

R45 15

C33 18

CR15

CR16

Q14

R52 100

R53 2K

R54 1K

C34 40

C35 .01

C36 40

R55 2K

C37 100

Q15

Q16

R57 1620

C38 4.7

C39 2.2

R58 10K

R56 51.1K

R59 3K

R60 56.2K

R61 33K

C40 35

R62 47.5

R63 100

R64 2K

C41 4.7

J2

J3

V

CR1

CR2

CR3

CR4

C4 20

R1 68.1

Q1

R2 2K

R3 2K

R4 6800

R5 11.3K

C6 4.7

C8 1.8

Q2

C3 .001

C1 65

CR7 6.98V

R6 4640

CR5

CR6

Q3

R10 16.2K

CR8

C2 65

R67 390

R11 14.7K

C7 20

C9 1.8

R7 2K

R8 2K

R9 68.1

Q4

C5 100

RANGE S2

E D C B A

RANGE

DB VOLTS DB

-10 .3 1 0

-20 .1 3 +10

-30 .03 10 +20

-40 .01 30 +30

-50 .003 100 +40

-60 .001 300 +50

RANGE S2EF S2ER

1. PART WITH FOR

2. COM WISE

3.

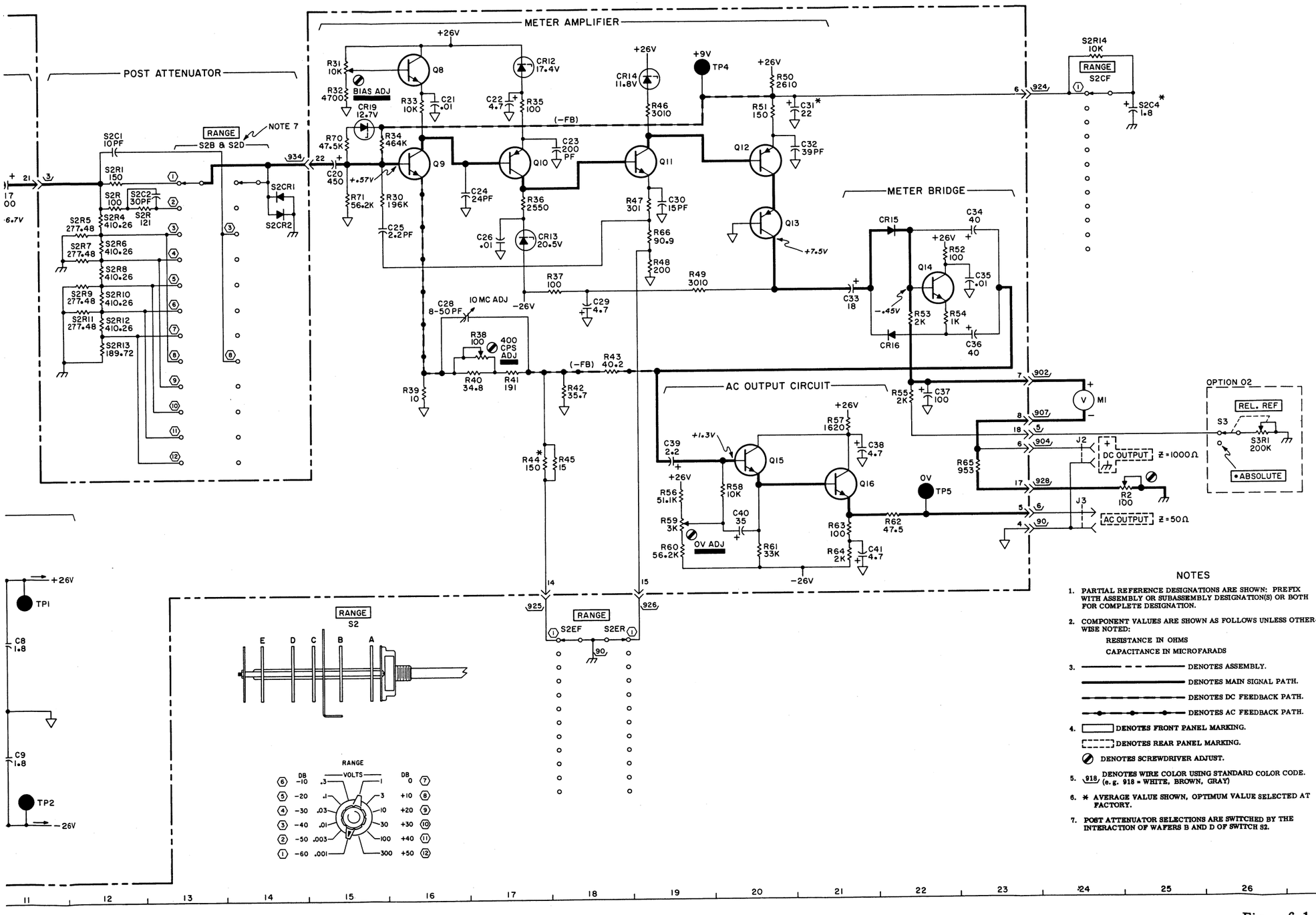
4.

5. 918

6. * A FA

7. POST INTE

4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24


METER AMPLIFIER
POST ATTENUATOR
METER BRIDGE
AC OUTPUT CIRCUIT
OPTION 02
RANGE
S2
NOTES
1. PARTIAL REFERENCE DESIGNATIONS ARE SHOWN: PREFIX WITH ASSEMBLY OR SUBASSEMBLY DESIGNATION(S) OR BOTH FOR COMPLETE DESIGNATION.
2. COMPONENT VALUES ARE SHOWN AS FOLLOWS UNLESS OTHERWISE NOTED:
RESISTANCE IN OHMS
CAPACITANCE IN MICROFARADS
3. DENOTES ASSEMBLY.
DENOTES MAIN SIGNAL PATH.
DENOTES DC FEEDBACK PATH.
DENOTES AC FEEDBACK PATH.
4. DENOTES FRONT PANEL MARKING.
DENOTES REAR PANEL MARKING.
DENOTES SCREWDRIVER ADJUST.
5. 918 DENOTES WIRE COLOR USING STANDARD COLOR CODE. (e.g. 918 = WHITE, BROWN, GRAY)
6. * AVERAGE VALUE SHOWN, OPTIMUM VALUE SELECTED AT FACTORY.
7. POST ATTENUATOR SELECTIONS ARE SWITCHED BY THE INTERACTION OF WAFERS B AND D OF SWITCH S2.

A2 SCHEMATIC COMPONENT LOCATIONS

	C	CR	Q	R	F		R
1	J8	G7	G9	G8	C7	46	B19
2	K8	G7	H9	H8		47	C19
3	J8	H7	J9	H8		48	D19
4	G9	H7	L9	H9		49	D19
5	L9	J6	C9	H10		50	A20
6	H10	J6	C9	J10		51	B20
7	K11	J9	C10	K8		52	D22
8	H11	K10	A16	K8		53	D22
9	K11	C7	B16	L8		54	D22
10	C7	D7	B17	J10		55	E22
11	B8	C10	B19	K10		56	F19
12	C9	A17	B20	--		57	F21
13	D9	C17	C20	--		58	F20
14	E9	A19	D22	--		59	G19
15	D10	C22	F20	C6		60	G19
16	B9	E22	F21	B8		61	G20
17	C11	B7		C8		62	G22
18	E11	E7		D8		63	G21
19	E11	B15		C8		64	G21
20	B15			B9		65	F23
21	B16			B9		66	C19
22	B17			D9		67	K9
23	B18			D9		68	B7
24	C17			E9		69	E7
25	C16			C9		70	B15
26	C17			D9		71	C15
27	--			E9		72	
28	D16			E9			
29	D18			E10			
30	C19			C16			
31	B21			A15			
32	B21			A15			
33	D21			B16			
34	C23			B16			
35	D23			B17			
36	E23			C17			
37	E22			D18			
38	F21			E17			
39	F19			E16			
40	C20			E17			
41	G21			E17			
42	B6			E18			
43	E6			E18			
44				F17			
45				F18			

Figure 6-1. 400E/EL Schematic Diagram and Location of A1 and A2 Components